J. W. MOLL

PHYTOGRAPHY

PHYTOGRAPHY AS A FINE ART

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AS A FINE ART

COMPRISING LINNEAN DESCRIPTION, MICROGRAPHY
AND PENPORTRAITS

BY

an illem
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WITH 7 PLATES

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This work is dedicated to the memory of ALPHONSE DE CANDOLLE, the author of the celebrated book entitled "La Phytographie", which originated the present work.

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FOREWORD

When Professor Moll died on Sept. 24th 1933 at the age of 82, the manuscript of his work "Phytography as a Fine Art" had been already deposited some time with the printing office of the well-known publishing firm E. J. Brill at Leyden who had undertaken the publication.

As to the reading of the proofs it had been agreed long before that this task would be deputed to the undersigned; Prof. Moll, even if he had lived, would have been unable owing to his blindness to correct them himself, and for his private secretary the work would have presented too many difficulties. For me on the other hand this was a welcome opportunity to render a certain service to the man to whom I owe more than I can express, and I am still very happy that my promise has made his mind easy on that score.

When therefore soon after his death the first sheets came, I began my task, but I soon recognized that the final retouching of the work had not been executed adequately, no doubt in consequence of the growing deafness of the last years, which more and more impeded Moll's working by the aid of a secretary.

I therefore asked the publisher for the return of the manuscript and revised it for that purpose. The numerous small changes I made were nearly all of a technical kind and do not interfere with the original meaning of Prof. Moll; neither do they alter the material contents of the work. If in any case there might be reason to enquire if some detail has been written by Prof. Moll in the same sense or in the very words, the unchanged duplicate of the manuscript may be consulted in the Groningen University Museum.

For the reading of the printing proofs I was so happy as to receive most valuable help from Miss Mabel Talbot at Plympton, Devon, to whom I wish to tender my best thanks.

The work of Prof. Moll which was so near to his heart and to which he devoted a considerable part of his life, will thus be finally presented to the botanical public.

No doubt many botanists, especially those of the older generation, *will shrink from the amount of work the recommended method of description brings with it. Yet even for such botanists the work may be a most valuable reference book, as the Synopsis forming the bulk of the volume gives a well-ordered survey of organographical and anatomical ideas and terms, all with explanations and examples; in this respect the work is rather comprehensive and surely unique in its kind.*

For those who want to make a trial with the method of Pen-Portraits, the value of the work may be much greater. If they are not easily daunted, they will no doubt realize sooner or later that no other method will ever be able to yield analogous results, and that their increased labour has been amply rewarded by the fruits, by the achievement of results which otherwise would have remained far out of their reach.

Botanical Laboratory of the State University
Groningen, July 1934 *J. C. SCHOUTE*

PREFACE

As a schoolboy I became highly interested in botany and commenced my studies as many of us have done by collecting wild growing flowers and making a small herbarium. Beginning my studies at the Athenaeum, afterwards the University at Amsterdam, there soon arose a lively, friendly and scientific intercourse with Dr. Hugo de Vries and by him I was before long brought under the suggestive influence of Julius Sachs, who was then at the height of his career. I became captivated by physiology in the physical direction and it soon became clear, that in other respects I could not be called a good botanist. My systematic studies were rather few and my herbarium remained strictly limited to the wild growing plants of our country. As a student I was often sneered at by my family, because most names of cultivated flowers in gardens were not only unknown to me, but especially because I was by no means ashamed of my ignorance. I never had an extraordinary love of flowers, and entirely missed what in India is called "the cold hand" (Tangan dingin). In other words I was quite ignorant of the art of plant breeding and although I often tried it and gave much time and many pains to it, I was never [1]) able to keep plants living, which were cultivated by my fellow botanists, and others, with the greatest ease. It may seem a paradox, but I am sincerely convinced, that this mentality was a factor and even an important one, among those which induced me to write this book. In all botanical work a thorough knowledge of plant morphology is necessary and he who is aware of lacking a more intuitive familiarity with the nature of plants will be therefore disposed to correct his intuitive weakness by means of a more intellectual expedient. Thence he will be obviously led to descriptions and if he should have disciples, he will induce them to study the art of phytography, which may be very useful and never disadvantageous for those among them endowed with a gift of more intuitive and spontaneous knowledge of vegetable organisms. I hope that the method of Pen-portraits will help many honest botanists of ordinary attainments in doing work which otherwise would have been out of their reach and also a few possessors of a more comprehensive genius in producing with greater ease, certainty and completeness, the richer harvest, which according to their greater talents may be anticipated.

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[1]) There was however a single exception. About the year 1900 I was occupied during many months with the cultivation of luminiferous bacteria and among hundreds or experiments failures either in fluids or on gelatine occurred only as rare exceptions. The technical part of Bacteriology is not difficult indeed.

Further it is a fact that there still exist numerous problems which in the present relatively defective state of phytography have not been solved, although a good description would suffice to bring them to an issue. Therefore improvements in the art of phytography may create the possibility of answering questions of various kinds and this has already happened.

I will not end this preface without mentioning that I have received help of various kinds in writing this work.

For the Synopsis of General Morphology which forms a principal part of it, I am indebted in many respects to the help of my colleague and successor Prof. J. C. Schoute for criticisms of the most various kinds, such as only a morphologist of very high standing was able to frame.

In the second place I am very grateful to three ladies, who have helped me as secretaries, which was necessary in consequence of the failure of my eyes. The greatest reliability was of course necessary here and they possessed it, but there was still an other requirement connected with the peculiar kind of my perception which belongs to a strongly visual and by no means to an auditive type. My ears could not replace my eyes, but my sense of touch could, and if Braille's splendid invention had not existed, this book could never have been written. But working with a secretary necessitates verbal intercourse which was very difficult for my helpmates and me; for I was obliged to condemn them to endless repetitions which must have been trying for their temper. But I have never and indeed never been able to discover any traces of bad temper in one of them, which becoming habitual, might easily have made our work impossible [1]).

Those ladies were: in the first place a young widow Mrs. van Eck-de Wiljes, in second marriage Mrs. Isenbart-de Wiljes, who had already had an important part in the finishing work belonging to Moll and Janssonius, Botanical Pen-portraits. She helped me afterwards in writing the anatomical part of the Synopsis in the present work, but was soon after married, and succeeded by:

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[1]) The possession of a visual or auditive type in blind or partially blind men is a very interesting subject which can of course not be treated in a work on phytography, because it is of a purely psychological character. Nevertheless Prescott, the American Historian, who was more or less in my case, may be cited here. In his History of the Conquest of Peru, London 1858, the preface contains some notices about his mode of working, which was, according to his auditive type, very different from what I have said in the text concerning my own mode of working.

Miss H. P. Voerman who worked for five years with me, finishing the Anatomy of the Synopsis and a great part of its Organography up to the root.

Miss B. C. Onnes, later Mrs. van Assen-Onnes succeeded Miss Voerman in the year 1928. She worked with me in finishing the Synopsis, but especially in writing the other four books of this work, till it was finished.

Lastly I may mention that I am indebted for the title of this work to Prof. A. C. Seward of Cambridge, who wrote in "Nature" Dec. 29th. 1923 an account entitled "Micrography as a fine art" concerning the work "Botanical Pen-portraits" by Moll and Janssonius. The heading of this very congenial account in the somewhat wider shape of "Phytography as a fine art" seemed to express what I wanted as a title for the present work. Accordingly I asked Prof. Seward permission to use this title, and hope that it will be appreciated by my readers as one really applicable, so that the work will do honour to its title.

PLAN OF THE WORK

This work is divided into five books and is closed by an alphabetical index, concerning which some explanations will be given below.

Book I. Phytography in past, present and future. This first part bears an introductory, somewhat theoretical character, dealing with the development of phytography and giving an exposition of the two principal levers used in this art. The first of these is a fixed, universal and rational terminology, based on what may at once be called General Morphology, an explanation of this term following afterwards. The other is the use of Guiding Schemes for facilitating the work of description and raising ist efficiency.

Book II. Synopsis, Morphological Notes and Guiding Schemes. This part bears a more technical character and is composed of three divisions: a Synopsis of General Morphology, with an appendix concerning diagrams; a collection of Morphological Notes giving explanations of several kinds and especially concerning controversial points; a collection of 88 Guiding Schemes.

Book III. Results of the application of the method of pen-portraits in Phytography and a few cases of its application in other sciences.

Book IV. Education in phytographical methods.

Book V. Historical considerations, text-books, and anticipations.

Alphabetical Index. This work containing an abundance of technical terms and of plant names, it might be anticipated that a large alphabetical index would be necessary to complete it. If all technical terms and plant names of the Synopsis were mentioned in the index the latter might contain perhaps 160 pages or more. The reader will find however that actually the index does not exhibit any extraordinary dimensions.

The reasons for this drastic limitation were not only of a practical kind, but the large index was also considered as for the greater part superfluous.

The names of plants being used as examples for technical terms are in a great measure arbitrary, so that they would seldom if ever be consulted here.

The technical terms in the Synopsis are arranged according to a definite system, a survey of which is given in the Table of Contents on p. IX. For sake of convenience it was however thought a good plan to insert the principal terms in the index. By the aid of them and by the progressive and retrogressive connections between the articles of the Synopsis, the reader will no doubt find the rest of the terms easily himself.

Finally names of persons were only inserted in those cases where the mentioning of their life or work formed to a certain extent an essential link of the argument of the text, not where their mentioning was only illustrative or accidental.

By these means the index could be kept within reasonable bounds without interfering too rudely with its practical usefulnes.

BOOK I.

PHYTOGRAPHY IN PAST, PRESENT AND FUTURE.

CHAPTER I.

THE DEVELOPMENT OF PHYTOGRAPHY.

The subject of the present work is the improvement of the art of Phytography in all possible directions. For this purpose it is in the first place necessary to take a historical view of its several stages of development; thus it will be possible to show by what means necessary improvements can be introduced.

As chief stages in the development of Phytography we may mention the Linnean method, in the first place in its general application, and in the second place as it has become specially adapted to micrographical purposes. Further the method of pen-portraits will be dealt with, which grafted upon the Linnean method and a rational micrography, may bring again some improvements.

§ 1. The Linnean method.

A. General application. It is not my purpose to give an elaborate history of the art of phytography, so that we may at once turn our attention towards the Linnean period.

If Würtz in his Dictionnaire de Chimie [1]) begins his Discours préliminaire with the sentence "Chemistry is a French science", this is a bold and in a general sense by no means a true assertion, but he is right in so far that indeed Lavoisier may be considered as the father of modern chemistry. In the same sense we may certainly say that botany is a Swedish science, for it is Carolus Linnaeus, who laid the foundations of botany in its present shape. In the first place he designated with the title of Species certain groups of similar plants, which he considered as the smallest ones, created at the beginning: species tot numeramus, quot diversae formae in principio sunt creatae [2]).

He gave to each of them two latin names, thus devising the so-called Binominal Nomenclature, which means that every species received two names, the first indicating the next higher group of plants or Genus, to which the species belongs, and the second being the specific name. This system has a strong resemblance with that of providing human individuals with names, which form the basis of so important an institution as the registrar's office. This exhibits also a binominal nomenclature, but in a reversed order, the christian name comparable with the specific name of the plant coming in the first place, and the family-name comparable with that of the genus in the second; nevertheless, for instance in Hungary, the family-name stands first, and is followed by the christian name.

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[1]) Ad. Würtz, Dictionnaire de Chimie, Paris, Hachette, T.I. p. 1. Discours préliminaire. Histoire des doctrines chimiques depuis Lavoisier. „La chimie est une science française."

[2]) Caroli Linnaei, Philosophia Botanica, ed. 4. No. 157 p. 172.
In Class. Plantar. 5, the definition is given in a slightly modified shape: Species tot sunt, quot diversas formas ab initio produxit Infinitum Ens.

Many controversies have arisen concerning the real worth of species; Darwin gave battle to their immutability and according to the views of most biologists of the present generation it was won by him, but be this as it may, the victory of Linné's binominal nomenclature has remained most complete, for nobody can deny that since its introduction it has constantly been used to the fullest extent. In the largest majority of all botanical papers and books, published during the last two hundred years, Linné's double names appear in a smaller or larger number. To suspend binominal nomenclature in botany would involve a most fatal break in the continuity of botanical publications, so that indeed a colossal revolution in the aspect of the foundations of our science must have occurred before there is the slightest chance that binominal nomenclature will disappear.

Another work of the highest importance was carried out by Linné, when, making use chiefly of the numbers of sexual organs in flowers, he composed his wellknown artificial system of the vegetable kingdom. With the help of this system chaos was replaced by order and from the date of its introduction an unheard-of progress in botany has taken place. The sexuality of plants was not the outcome of Linné's own investigations but it was a novelty, in which however it was by no means fashion for orthodox botanists to believe. Linné accepting sexuality in plants as a wel-established fact and using it as the basis of a comprehensive system, was accused of violating the spotless purity of plant-life. In our days this opinion may seem somewhat strange, because to sexual reproduction every individual in mankind owes its origin and it seems curious, that the life of plant should be soiled by exhibiting a phenomenon of such common occurrence in the animal kingdom. But let us keep in mind that through all history there are running notions concerning the impurity of sexual reproduction. It is however certain that after the general introduction of Linné's artificial system, such objections against sexual reproduction in plants have altogether disappeared and a fertile period of botanical investigations was opened. Even now, although what we call the natural system has in general replaced it, Linné's artificial system in its simplicity has by no means been totally relinquished and in many school-books it still appears together with the natural system.

It is obvious that a conception, like that of Linné's plant species cannot be carried through without having the disposition of accurate descriptions and with respect to Linné's artificial system the same may of course be said. Therefore Linné was obliged to devise a method of phytography and like all his work he did it so thoroughly, that at the present time it may be still used unaltered.

In working out his method of Phytography Linné met of course with the same difficulties which every one who describes complicated structures must meet. Our power of describing with accuracy the shape of a body is in fact restricted to the use of relatively few terms for designating stereometrical figures, like sphere, cylinder, prism, etc. and for this subject the reader is referred to article No. 31 of the synopsis, where it has been treated in detail. It may suffice to say here, that in consequence of this circumstance mostly an analysis and often a reiterated one is required before the use of a well defined mathematical term becomes available. Leaving whole trees, flowers, etc. entirely out of the question and confining ourselves for a simple example to an annual shoot of the current year, bearing in summer a certain number of foliage leaves, we find that an analysis into stem and leaves must be the first step, that probably the leaves must be again divided into leaf-stalk and blade and that a further analysis of the latter certainly will be wanted, before any geometrical explanation can be applied. Moreover there are several leaves and it is obvious that in describing them the first step should be to determine their number and their reciprocal arrangement before thinking of an analysis. The phytographer must begin by the same proceeding as well as everyone, who describes bodies of any kind whatever exhibiting complex external shape. It is only the ordinary basis of all such descriptions: indispensible, but not peculiar to the Linnean system.

Now proceeding to deal with the more special characters which ought to be exhibited by phytographical productions, it must be brought forward that descriptions of plants may be used for two purposes. In the first place they must be able to awake in the reader's mind an image of the investigated objects, clear and as complete as circumstances allow. If such a purpose is attained, this knowledge can be very useful especially for the solution of taxonomical questions, and it is natural that, comparison between several images being necessary, strict regularity in the order of sequence of the subjects mentioned in the description is wanted, but for the rest the character of the style is not a matter of great importance and the object of the description might be reached in different ways, a somewhat readable style being perhaps even preferable. But there is another end, for which plant descriptions are indispensible: they ought also to be fit for rapid consultation concerning certain particular points, of which the knowledge may be wanted in the course of all kinds of botanical work. The formation of an image in the mind of the reader being from a purely scientific point of view the most important function of a description, we may nevertheless say that fitness for rapid consultation must be desired in the very first place, so much the more, because it need by no means interfere with the intrinsic value of the description. Linné therefore made use of all available means for attaining this object, which may be fully characterized by the single word brevity; a maximum of information with a minimum of words being the ideal, of course mounted on a scaffolding of an automatic order of sequence, like mentioned above. The most efficient means for obtaining the utmost brevity was found by Linné in the use of technical terms and for this purpose he constructed in his Philosophia Botanica a complete terminology concerning the external organisation of the higher plants, which in substance is still in use at the present day; although in the course of almost two centuries, an enlarged knowledge has necessitated here and there some alterations. Terminologies concerning the organography of the lower plants like Thallophyta and concerning the anatomical structure of the whole vegetable kingdom were afterwards added by others, but the principle has remained the same. Now it is clear, that the use of well defined technical terms is the very best means of economizing the use of words in descriptions of all kinds. In a term consisting of a single word there may be condensed a certain quantity of information.

In many cases the same information could be given in a small sentence, say of ten words, but if these are replaced by a single word the reduction is already very important. Moreover there are other terms, like cormus, phyllome, flower, etc. whose explanation might require considerable space, and the more so, because in a definition of one term often the knowledge of other terms may take part. This concatenation of terms is indeed an important factor in the enormous power of economizing words as exhibited by botanical terminology.

It is obvious that, when words of daily life are used as botanical terms they receive another special meaning, so that terms like stem and leaves, inflorescences, flowers, fruits and seeds losing more or less their original and ordinary meaning, stand in botanical descriptions for designating special characters which in ordinary life nobody would think of. In this respect the use of the Latin language presents some advantage, but I do not think that it is of any real moment.

It is further a fact, that Linné composed his descriptions almost entirely of such botanical terms, so that at one blow the most perfect brevity ensued. The only other essential element of Linnean descriptions is formed by their punctuation: a row of technical terms, all concerned with one and the same subject is terminated with a full-stop, the successive terms themselves being separated by comma's; and new paragraphs may occur if they are wanted. Obviously in this way no real sentences are formed in these descriptions, for verbs are wanting because totally superfluous and prejudicial to brevity. If we want to speak of style with respect to such descriptions, the term telegram-style would perhaps be suitable. In this way descriptions are formed which for true laymen in botany are quite illigible and comparable to cryptograms, written with the help of an unknown secret code, but for botanists of the old style their readability is not impaired. However when dealing with the method of pen-portraits, we shall afterwards find, that more modern botanists have felt this want of superfluous verbs as a real disadvantage, an opinion to be revised however as soon as possible.

Summarising we may say that the Linnean method of description by its rigorous order of succession, fixed beforehand, insures completeness as far as other circumstances will allow it, because nothing can be forgotten in its place, whilst annoying repetitions will be avoided by the same means. Thence they are capable of calling before the reader's mind reciprocally comparable images of the objects treated by them, and at the same time they possess a fitness for rapid consultation coming near to that of a dictionary.

A last advantage of the Linnean method, which may be mentioned here, is that it opens opportunities for subsequent extension and improvement without the necessity of composing a whole new description. Thus the work of predecessors is not lost, but fully used, avoiding new errors inseparable from every new production. In this way a continuity which may be estimated to be of the highest importance for botanical literature, is obtained. A case in which this continuity was painfully missed will be reproduced below, where the importance of the method of pen-portraits for the description of the vegetable drugs in Pharmacopoeiae is discussed.

Augustin Pyramus De Candolle has said in his Théorie élémentaire [1]), speaking of the Linnean method of description, that the peculiar and natural talent of the writer almost disappears in this style, where all has been regulated beforehand; we see men without spirit, without genius, write books almost as good as men gifted with both qualities — in a word, if the books became more exact they became also more monotonous and more tiresome. It is perhaps not strange that A. P. De Candolle, the author of the Prodomus Systematis Naturalis Regni Vegetabilis, was slightly irritated by the thought that many parts of his valuable work might have been written by men without spirit and genius as well as by himself, and that such a feeling is projected upon the Linnean mode of description, so that it is called monotonous and tiresome. Nevertheless this criticism by De Candolle is by no means just. In the first place a dull and narrow man was certainly always unable to write a good Linnean description and especially at the present time, when so much more is known about the complications in the organography and anatomy of the higher plants. Nevertheless men without spirit and genius need not be dull and insipid; they may possess average qualities of mind, which combined with application and diligence, will make them fully capable of writing good Linnean descriptions. This is indeed a work, for which no men of spirit and genius are needed. By making innumerable good Linnean descriptions, no botanist will be able to gather the laurels for wreathing his temples as a man of genius. On the other hand, if by chance a method could be devised enabling dull men to produce really good Linnean descriptions, this would certainly be a great and most unexpected boon.

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[1]) A. P. De Candolle, Théorie élémentaire de la Botanique 2 éd. 1819 p. 288. „Le talent propre de l'écrivain disparut presque dans ce style où tout est réglé d'avance; on vit des hommes sans esprit, sans génie, faire des livres presqu'aussi bons que ceux qui en étaient doués; en un mot, si les livres devinrent plus exacts, ils devinrent aussi plus monotones et plus ennuyeux."

A. P. De Candolle himself has for the rest amply shown that the spirit and genius he possessed in so high a degree, even if not necessary in ordinary phytography, nevertheless may find scope in numerous other branches of botany.

With respect to De Candolle's remark, that Linnean descriptions are monotonous and tiresome for the general reader, it must be conceded that this is anyhow a matter of small importance, not to be considered as a valid criticism.

Moreover I hope to convince the reader below, that the method of pen-portraits by adding to the technical terms observations in ordinary language, but retaining the telegram-style, creates opportunities for less tiresome informations. Hence the character of a signalment in a pass-port clinging more or less to a simple Linnean description makes place for that of a portrait and it is indeed not easy for men really without spirit to write good "pen-portraits".

It is perhaps well, before leaving this subject, to point out a difference between De Candolle and Linné which may also account more or less for De Candolle's opinion. If we consult his Prodomus, we find that his diagnoses contain almost nothing but technical terms and marks of punctuation. On the other hand the genius of Linné being certainly of a curiously comprehensive and even here and there of a somewhat wild description, we find in consulting his Species Plantarum that the rules of the game are not so strictly followed as in De Candolle's Prodromus, whilst in the appendices added to his descriptions, even a verb has here and there made its appearance. Moreover the author of a general rule is often found to be less strict in the application of his own creation than his followers, and many among the latter, in the case of Linné, have amply proved by the servility of their work the exactness of the foregoing remark.

After so ample a discussion the reader will not be astonished to learn that the Linnean method of description has been applied fully and unaltered in principle in phytography and in the method of pen-portraits, as well as it has been done during nearly two hundred years in the organography of the higher plants.

B. Application of the Linnean method of description to Micrography. The term micrography properly designates in a general sense all descriptions of the objects and structures, too small for being distinctly seen with the naked eye. It is clear, that although answering to the above definition, descriptions of the most different kinds of objects and structures might be united together. The term may however be also used in a more restricted sense for indicating the description of anatomical structures of small dimensions, in a word, for cytological and histological work. Although not a very expressive term, it has been daily used during many years, for designating anatomical descriptions in the botanical laboratory at Groningen, whilst the development of the method of pen-portraits took place at the same time, so that this was included in the term micrography as it was then used. When the method of pen-portraits is treated in detail below, the peculiar historical relation existing between micrography and the method of pen-portraits will be amply dealt with.

By reading the beautiful book entitled "la Phytographie", written by Alphonse De Candolle, to whose memory the present work is dedicated, I had been convinced that in the usual cytological and histological descriptions the Linnean method had in most cases not been used and that often in papers concerning such subjects there was no question at all of regular descriptions, so that these papers rather exhibited the character of elaborate dissertations. I was so much impressed by De Candolle's considerations that I resolved at once to try what could be done in this direction and about the year 1895 I commenced to apply the Linnean method in descriptions of cellular elements and tissues, so that uniform and comparative results ensued. As has been remarked, the application of the Linnean method to micrography was united at once to the development of the method of pen-portraits, but we will defer this subject till below when the method of pen-portraits will be dealt with in detail.

I delivered a lecture every week for pharmaceutical students at the University and in each lecture the anatomical structure of one or two vegetable drugs was dealt with. Thus I had occasion to try my own hand at this kind of work. Moreover students were led in the same direction: a few biological, among whom my future successor Prof. J. C. Schoute, and a larger number of medical and pharmaceutical students, several of them highly interested in the question.

It appeared at once that Linné's strict order of sequence of the subjects and telegram-style could be applied without any difficulty. But there were two very natural obstacles. Firstly in the major part of microscopical work the use of thin sections, in at least three planes, is necessary and often their number may be greatly increased. Descriptions of such sections are however incomplete, because they cannot take into account that cells and tissues are objects with three dimensions and ought to be described as such. In other words, it seemed to me but natural that a good phytographer was under the obligation to combine his three or more original descriptions to which I gave the name of empirical descriptions into a single perspective description, and that the reader might with good reason have objections to doing so himself. Thus in micrography only perspective descriptions could be tolerated.

In the second place it soon became clear, that for purposes of consultation, so very important in micrography, it was absolutely necessary that in the wording of anatomical descriptions, tissues and cells should be kept apart. In articles of this kind there ought to be distinguished on the one hand a topographical part or Topography, dealing with the characters of the several tissues and their reciprocal arrangement, on the other hand Cell Descriptions, exhibiting a purely cytological character. Only by doing so a complicated anatomical description, for instance of a stem, a leaf, or a root will become fit for rapid consultation; and as a general rule, it may be said, that it is not a good plan to separate a description into two parts, the first containing the whole topography of the organ, and the second all cell-descriptions in an interminable row. On the contrary the topography must first be divided into its several parts, and to each successively the cell-descriptions belonging to it must be added; in many cases their number is moderate or even small, but in a few cases, when more complicated kinds of tissues occur, the number of cell-descriptions belonging to one and the same kind of tissue may become rather large, for instance in descriptions of secondary phloem and xylem; but this is no objection and will not diminish the suitability for consultation, because the several cellular elements belonging to such natural divisions of tissues are nearly related and will be often wanted together. In many cases the student will only want topographical facts, and if cytological data are desired they can be most readily found in the isolated cell-descriptions. With those important, but easily applied modifications the Linnean method of description was used for many years at Groningen, and from the beginning the method of pen-portraits was added to this micrographical work, but this is a subject to be dealt with below.

Before leaving the subject of the construction of the rather complicated micrographical descriptions, I will deal with what might be called abbreviated descriptions. If a certain number of objects are to be described, which in a high measure resemble one another, we can of course unite together all characters exhibited by all of them into a general description, thus applicable to the whole group. In describing the members of the group these characters are not repeated and only the special characters of those members appear. This is of course the ordinary way for treating such subjects in systematical works, meant for propagating general knowledge. But there are also works, in which another distribution of subject matter is preferable, as proved to be the case in our Mikrographie des Holzes der auf Java vorkommenden Baumarten. In describing the woods belonging to one and the same family of trees, a general description of the wood structure is given in the first place. Further on, the wood of the species of the several genera, belonging to the family, is treated, but the structure of those descriptions is not always the same. In every genus containing more than one species, there is one full description, but for the rest we find only what we have called above abbreviated descriptions. This means that all that has been said in the full description and is applicable to the species of which an abbreviated description is made, has been omitted, and only those particulars, which are different from the full description have been described in the abbreviated one. The reader of the abbreviated description is supposed to read the full description, but with the alterations made in the abbreviated one. This procedure may seem somewhat complicated, but there are good reasons for it, which however are of only a purely practical character and have not the slightest theoretical value. If all descriptions are treated as full descriptions, the investigator will be obliged for every species in the genus, to make anew a description of all generic characters and this will take much more time than simply to examine his sections to find out whether the generic characters are present. Moreover the repetition of all generic characters in every description will tend materially to increase the bulk of such a book as the Micrographie des Holzes. Thus the only object of the abbreviated description is to save time and money.

Evidently abbreviated descriptions need not be restricted to micrography, and there is in principle no reason why they should not be used in organography; but I am unable at present to see in what cases it would be necessary to do so.

As has been mentioned above I was led to the application of the Linnean method in micrography by Alphonse De Candolle's reflections concerning this subject in his Phytographie. It is however worth while to inquire what other botanists have done for a more rational development of micrography, and here it is in the first place necessary to examine the application of the anatomical method in the classification of plants. To this subject a rather large number of botanists have directed their attention, and an excellent treatise concerning it has been published many years ago by Dr. Th. Valeton [1]). To an outsider it would seem obvious that in the science of Linné all investigators, trying to use anatomical characters in classification, would in the first place have applied Linné's well-known method of description, which for many years had reigned with so much success in this branch of science; in other words, that their first care would have been to furnish the necessary complete micrographical data for their purpose. But nothing of this kind has occurred. All those who have tried to work out plans of this sort, and their number was considerable enough, have contented themselves with trying what some more or less special anatomical characters could accomplish for them in special cases of classification. It was always an attempt to use anatomy as a means, accessory and complementary to the more complete organographical description, often leading to a more rapid, easy and secure determination. It seems to have come into nobody's head that possibly anatomical characters might in their kind have a great value, by no means yielding to that of organographical ones, so that it would have been worth while in all cases to add anatomical descriptions, as careful and complete as the organographical descriptions, which in systematical investigations, botanists have used since the beginning of the Linnean period.

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[1]) Dr. Th. Valeton. De anatomische methode in de classificatie der planten. Programma van het Gymnasium te Groningen voor het jaar 1888—1889, Groningen 1888, with 92 pages and a very interesting list of literature on the same subject. It is a pity that this paper has not only been written in the Dutch language, but also has been published in a school program, so that it may be said to have been securely withdrawn from all chances of being consulted. It would be a good thing, if as yet a translation could be made including the list of literature and the whole published in a botanical periodical.

In Valeton's paper the reader will find many examples of such proceedings, but it will suffice to treat more in detail a single one, considered to be of special importance at the time when Valeton wrote. In the year 1883 Ludwig Radlkofer of the University at München at a solemn meeting of the Bavarian Academy of sciences, in presence of the Prince Regent, delivered a long oration [1]), concerning the methods in systematical botany, especially the anatomical method. This speech is a most curious monument of German „Weitschweifigkeit", or prolixity, a phenomenon which has happily well nigh disappeared in modern German botanical papers. The writer's ample investigations of 1875 concerning the genus Serjania, belonging to the family of Sapindaceae are cited [2]). They certainly are of considerable interest, but not from a phytographical point of view, as has been set forth above. The same may be said of further investigations of the same kind, published some years after his speech in the Academy of sciences [3]).

Solereder, a pupil of Radlkofer wrote afterwards a book on a systematical anatomy of Dicotyledons [4]), containing a large mass of interesting anatomical facts, especially on the structure of appendages of the surface, a book, very commodious for consultation in the laboratory. But there again we seek in vain for anything like a regular method of micrography.

Although in purely botanical scientific work nobody had been able to apply Linné's principles to the foundation of a regular micrographical method, there was a branch of applied botanical science in which meanwhile better progress was made. In pharmaceutical botany the anatomical structure of vegetable drugs had strongly attracted the attention of many investigators. In connection with the development of the microscope and its manipulation many investigations had taken place, concerning the anatomical structure of vegetable drugs, and it had become clear that in microscopical research a mode of identification could be found by no means inferior to the use of macroscopical characters. During the first period of this Pharmaceutical micrography however, no use of Linné's rules occurred to the extent that we could speak of the application of the

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[1]) L. Radlkofer, Ueber die Methoden in der botanischen Sytematik, insbesondere die anatomische Methode. Festrede gehalten in der königl. Akademie der Wiss. München 25 Juli 1883. Verlag der Akademie.

[2]) In the year 1886 there appeared moreover „Ergänzungen zur Monographie der Sapindaceen-Gattung Serjania." K. Akad. München. Cl. II. Bd. XVI, Abth. I.

[3]) Radlkofer, Monographie der Sapindaceen-Gattung Paulinia. Abh. d. II Cl. d. k. Akad. d. Wiss. München Bd. XIX. Abth. I. 1895.

[4]) H. Solereder, Systematische Anatomie der Dicotyledonen, Stuttgart 1899, and Ergänzungsband 1908.

Linnean method of description. Readers interested in these matters may be referred to Moll and Janssonius, Botanical Pen-portraits p. 1, where this subject has been expressly treated. They will find that Oudemans (1854—1856) and Berg (1865) have introduced for the first time microscopical work into Pharmacognosy. Several valuable works treating the same subject matter followed afterwards, like those of Tschirch (1889), Arthur Meyer (1891—1892) and Tschirch und Oesterle's Atlas (1900), but for our purpose, the use of a micrographical method, they have as little interest as those of Oudemans and Berg.

Before leaving this subject I will however mention L. Koch's Pharmakognostischer Atlas 1911—1914. Although the principal feature of this work is formed by its beautiful plates, there have been added rather elaborate descriptions, showing a decided regularity, which makes them fit for consultation, and this certainly is a very real progress. Nevertheless this regularity is of such a kind that these descriptions cannot be considered as good applications of the Linnean method in micrography. We may say so, because the telegram-style is wanting, as well as the perspective character of the descriptions and the separation of topography and cell descriptions.

In yet an other branch of applied botany viz. the knowledge of timbers from a commercial point of view, we find two interesting works, which contain short anatomical descriptions of many woods. These works are: J. S. Gamble, A manual of Indian Timbers, London 1902, and Herbert Stone, The Timbers of Commerce and their Identification, London, Paris, New-York 1904. For the sake of completeness they may be mentioned here, but these anatomical descriptions, although good in their kind, are for similar reasons by no means better examples of the application of the Linnean method, than those of Koch, cited above.

Summarising we may say that the result of our examination is disappointing. I was unable to find even a single example of the application of the Linnean method in micrography giving satisfaction. It is indeed not to the credit of botany, that none of those, who seemed to be very near to it, has tried to graft on micrography a method of description, of which for almost two hundred years the results had proved its excellence in the organographical branch of classification. From all this ensues the necessity of introducing as soon as possible so useful a method, and the reader will not be astonished that it has been also used as one of the bases on which the method of pen-portraits was erected. Its sterling qualities have become apparent here also as will be shown below.

§ 2. The method of Pen-portraits.

In Schopenhauer's Parerga und Paralipomena, there occurs a curious passage, in which we find clearly expressed the essential character of the method of pen-portraits. He says: to the discovery of the most important truths the observation of the rare and hidden phenomena, only to be produced by experiments, does not lead; but rather the observation of the openly displayed phenomena, accessible to everybody. Therefore the problem is not so much, to see what nobody has yet seen, but rather to think concerning that which everybody sees, what nobody has yet thought [1]).

We certainly must not take this assertion too literally, and we may even say that it is tuned to a somewhat high pitch. In the first place there is no doubt that the observation of such phenomena as can only be produced by experiments have often led to the discovery of highly important truths. On the other hand I cannot pretend to say with sufficient certainty, that the method of pen-portraits will lead to scientific truths of the very first rank. It also is not concerned with entirely new thoughts, but only with thoughts of a very simple kind, which hitherto have been rather neglected in the practice of phytography. Lastly it must even be allowed that all truths, which may be found by means of the method of pen-portraits might be found also with the help of other methods, but the method of pen-portraits certainly is a regular and well-smoothed access towards purposes of this kind.

Granting all this it may be maintained that simple thoughts, never brought forward before in this connection concerning certain observations may be a means of discovering truths worth knowing in phytography. To lead students in such a direction is the object of the method of pen-portraits. It has indeed been devised for the purpose of penetrating deeper into the knowledge of plants, than the most complete organographical and anatomical Linnean descriptions can reach. Those descriptions, because they are composed almost exclusively of technical terms, can only reproduce that which has been so thoroughly examined by preceding investigators, that the results of their observations can be condensed into a term. For this very reason however, he who thinks concerning the object of his observations what was not thought before, cannot express these new thoughts exclusively with the help of technical terms, although he may of course use in his explanations some of them on points of secondary import.

Thus it would obviously be profitable, to open a way for adding to the terms of the Linnean description further particulars concerning them, retaining indeed the telegram-style, but further expressed in a free language, adequate to communicate free roaming thoughts. By doing this, in other words by introducing into phytography the method of pen-portraits, all descriptions could be brought at once up to a higher level, because they would contain particulars which at present belong to the domain of habit — using this term in the sense of the synopsis No. 16 — or again particulars which are now to be expressed only in pictures. If words can be found to express such floating characters, they are brought into a circle of higher scientific rank. Such additions would alter the character of every description: from a mere registration and arrangement of known facts it would be at once lifted up into the sphere of simple scientific investigations, because the student during his work would be continually scenting for new points of view, from which he may be led to a more thorough knowledge of the object he is describing.

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[1]) Schopenhauer, Parerga und Paralipomena, in gesammelte Werke (Frauenst.) Vol. VI, § 77, p. 115. The original text runs as follows: „Ueberhaupt aber wird zur Entdeckung der wichtigsten Wahrheiten nicht die Beobachtung der seltenen und verborgenen, nur durch Experimente darstellbaren Erscheinungen führen; sondern die der offen daliegenden, jedem zugänglichen Phänomene. Daher ist die Aufgabe nicht sowohl zu sehen was noch keiner gesehen hat, als bei dem was jeder sieht, zu denken was noch keiner gedacht hat."

I may now add some particulars concerning the several phenomena, which may be introduced into pen-portraits.

A certain number of simple characters and conditions which may be needed in descriptions of objects belonging to the plant kingdom, will be dealt with below in the general part, belonging to the Synopsis of Ceneral Morphology, S. No. 30—37, and for full information the reader is referred to these articles. A few short indications may find their place here. The following subjects have been worked out in the synopsis: shape, dimensions, chemical composition, conditions of colour, conditions of consistency, conditions of surface and statistical data. Among these, shape, dimensions and statistical data are of particular importance for pen-portraits.

With respect to shape on consulting art. No. 31 of the synopsis, the reader will find an enumeration of the several bodies, distinguished in Stereometry and added to each of them a certain number of mathematical terms for parts constituting them. Thus the phytographer, when he has reached in his description the elementary parts of complicated structures is enabled to indicate the places where irregularities occur and describing the latter, the image of his object will be enriched in its details.

With respect to dimensions, on consulting art. No. 32 of the synopsis, the reader will find a complete set of symbols or abbreviations to be used for designating not only the dimensions, but also their several directions. It is clear that for all objects these are characters of the highest importance, and although in the older Linnean descriptions dimensions are generally wanting, we find in more modern works numerous statements concerning dimensions, which may be considered as precursors of the portraying method. In micrography data of this kind are still more important than in organographical descriptions, and we may even say that an anatomical description is imperfect as long as dimensions and their directions of all cellular elements are not known.

With respect to statistical data concerning numbers, dimensions, weights, intensity of colours, and many other characters, on consulting No. 37 of the synopsis, the reader will find again a complete set of abbreviations, which may be used, if the student wishes to apply statistical methods. These methods themselves cannot be treated here, but for the necessary information concerning this subject the reader is referred to Johannsen's Elemente [1]).

Of course the other general characters and conditions mentioned above can also afford a variety of traits for a pen-portrait and the phytographer must not omit to consult in these respects Guiding scheme No. 8, containing a variety of characters not mentioned in the organographical and anatomical guiding schemes, because no special technical terms are in use for them.

The portraying parts of phytographs can be of course extended at will and even lead to serious investigations. But portraying can also be applied on a more modest scale in the ordinary course of phytography, and what has been communicated here and in the synopsis will suffice fully for applications of this kind.

Can pen-portraits be attractive and readable? Some readers will perhaps, forgetting that the title of the present work is "Phytography as a fine art", feel inclined to answer both these questions in the negative. Nevertheless it is undeniable that a pen-portrait can to some extent be a thing of beauty, although it always will remain a beauty of an unassuming kind; but verbs are by no means indispensible for a good style, so that a telegram style can very well show a certain modest beauty, as will be known very well to journalists and men of business, who extensively use this mode of communication. Moreover a pen-portrait from its nature, as explained above, allows a good chance to the individuality of the phytographer for exerting its influence. I have always tried myself to produce descriptions not lacking good taste and I sometimes was able to reach a certain satisfaction with my work, necessary to be fulfilled before an artist of whatever kind can regard his own work as finished. On the other hand the author's satisfaction procures by no means certainty that his fellow men will be of the same mind.

If a description can be beautiful, it must certainly in the first place be readable. In this respect however it is perhaps well to observe that our modern botanists often are unable to read long descriptions from sheer hastiness. This is an art in itself, indispensable for readers of systematical treatises, not so much for those on physiological subjects.

§ 3. Materials for making Phytographs.

Before leaving the subject, entitled the development of phytography, it is necessary to say something concerning the materials used in this art. Obviously the fundamental materials for making descriptions must be the plants themselves. Nevertheless there are often needed and indispensible in botany general descriptions of larger groups of plants, which for practical reasons it is impossible to make from the plant material itself. They must be composed by a judicious combination of other descriptions, which have been based upon plant material, and may be called here combination descriptions.

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[1]) W. Johannsen, Elemente der exacten Erblichkeitslehre 3. Aufl., Jena 1926, p. 21.

A. Plant material. Concerning the general character of plants or parts of plants, which are used as subjects of descriptions, we may say that they are always individuals, either reproduction-individuals or organ-individuals (see for the meaning of these terms synopsis No. 9), but the cases in which really a single individual is described, are very rare. There may however be circumstances in which the phytographer has only a most incomplete material at his disposal, like sometimes in herbarium work and paleontological investigations. In ordinary phytographical work however there is, as far as I can see, but one instance, in which only a single individual is described. This is the case in Genetics, when in genetics a plant is described, which is destined for experiments concerning its reproduction, crossing and offspring.

In all other cases the material for descriptions is usually formed by smaller or larger groups of individuals. If these are reproduction-individuals they coincide in the majority of cases with existing well-known subdivisions of the vegetable kingdom, provided with their own special names, like varieties, species, genera, families. Groups of this kind are daily used as material in systematical botany, and we may even say that for Linnean descriptions students of this branch of botany will presumably remain always the best customers.

In some cases however groups may be formed not on the basis of consanguinity, but for instance because some plants are adapted to the same external conditions, like hygrophyta and xerophyta, epiphytes, parasites, saprophytes, mangrove plants, and so forth.

When however the groups are formed by organ individuals, they are never provided with their own names, but they are composed of those objects which the phytographer happens to want for his work in each special case. Describing the foliage leaves, bud-scales, petals, stamens of a plant species, the student will probably make use for his description of several branches, buds and flowers belonging to this species and will probably gather them also from several individual plants of the same kind. In the case of anatomical descriptions the student will mostly make use of several, often a large number of thin sections in different directions, taken perhaps from several individuals of the same species or variety, so that he is furnished with groups of objects, which are however unnamed, and here again the description of only a single cellular element, etc. will be a most exceptional case. Cell descriptions in micrography are for instance almost always composed from the observation of a large number of cells, belonging to the same tissue, and even in the case of isolated idioblasts the student will try to use observations, made on a certain number of this kind of cellular element and rarely he will have cause to restrict his description to a single individual.

From the preceding considerations it will be clear that all original Linnean descriptions ought to be supplied with a full statement concerning the plant material on which they are based, because thus only the intrinsic value of description can be judged.

B. Combination descriptions. In theory it seems clear that in all cases whatever it would be possible to make descriptions using plant material, either in a living or in a preserved condition. But where descriptions are needed in systematical botany of large groups, like genera, families up to the principal divisions of the plant kingdom, and where as in the latter cases the groups which must be brought together, consist again of numerous components, it will be very difficult, perhaps impossible even for investigators possessed of a vast psychical capacity, to make at once from the raw material a combined description. Moreover there are many obvious, practical drawbacks against such a proceeding. In such cases there is however not the slightest objection to combination of existing descriptions based on plant material, because in such combinations the full influence of the original material remains active.

CHAPTER II.

GENERAL MORPHOLOGY AS A BASIS OF PHYTOGRAPHY.

It is now my task to give the necessary explanations, announced above, concerning the meaning of the name General Morphology, so often used in this work. I use this term for designating the knowledge of external and internal shapes and conditions belonging to plants, and I will show at some length what are the principal characters it ought to exhibit, especially with a view to the technical terms, which it contains in large numbers, and which are of primary importance for purposes of phytography.

In the first place it must deserve the epithet "General" by its completeness. This does not mean that technical terms ought to be available for all characters shown by a plant. It is evident that this is impossible and will remain so for a long time to come, because the existence of every technical term proves that a certain knowledge concerning a certain character has been won, and we all know that every plant has many striking characters, which cannot be expressed in words. The reader is referred for more particulars concerning this question to article No. 16 of the synopsis, where the term "habit" has been treated. General however it must be in so far as it should contain a terminology adapted to all plants, which are known at the present time in botany, for we must be able to make pen-portraits of all these.

In the second place it is evident that in General Morphology there is needed a terminology, showing as much as possible a quality of pure objectivity. It must be free from the influence of theoretical conceptions concerning unsolved problems of a systematical or physiological nature. Thus only, worked out in a somewhat agnostic kind of mentality, unbiassed by preconceived ideas, this terminology can afford valuable help in their descriptions to those who are occupied with the solution of problems concerning all kinds of vital phenomena. Independent of all existing theories, phytography must produce unimpeachable results; if Darwinism should unexpectedly go down tomorrow, our descriptions must remain unassailable, and available for the foundations of a new theory. It is perfectly true that many botanical terms, perhaps even the majority of them, have originally been devised and published in papers of all kinds by authors, whose mind was full of theoretical considerations, and for this reason, a certain number of terms proposed in literature are not fit to be used in phytography. Schwendener in his well-known book dealing with the mechanical principle in the anatomy of Monocotyledons [1]) laid the foundation of what might be called an Oecological Anatomy, and his disciple Haberlandt has worked out this system [2]). It is natural that in these works new anatomical terms have been introduced, and old terms altered with respect to their meaning and that old and new terms both are thereby lacking the objectivity, which according to my above considerations could only fit them for general use in Phytography.

But in most cases it will be easy, if more or less ambiguous terms can otherwise be of service, to separate them from their theoretical ballast by using simple and clear definitions.

I further must mention that the term General Morphology has been used already in another sense by more than one author. I will show that nevertheless there is no reason to give up the use of the term as it has been defined above.

In Botany Julius Sachs has used the term in his wellknown textbook. The subject matter in this work is divided into three books, the first is called General Morphology, the second Special Morphology and Outlines of Classification, and the third Physiology. The General Morphology of Sachs contains indeed much material exhibiting a very important and even general character. The complete anatomy of plants, further symmetry, ramification, are dealt with and the terms thallome, caulome, phyllome and trichome are clearly defined, so that indeed the term "general" might well be used for this section of the work. It is only a pity that Sachs to his Outlines of Classification has added what he calls Special Morphology, instead of finding accomodation for all this material in his General Morphology, a proceeding against which evidently no objections from principle could have been raised. Taking into account the foregoing considerations I have not hesitated to use the term General Morphology in a wider and more real sense than Sachs, because I did not think that a break of continuity could ensue, which might be dangerous for our science, especially in Phytography.

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[1]) S. Schwendener, Das mechanische Prinzip im anatomischen Bau der Monocotylen, Leipzig, 1874.

[2]) G. Haberlandt, Physiologische Pflanzenanatomie, 4 ed. Leipzig, 1909.

In Zoology the term General Morphology has also been used, but here in a wider sense than I have done. Another illustrious scientist Ernst Haeckel, in his well-known book entitled "Generelle Morphologie der Organismen" of which the first edition dates from 1866 defines morphology (p. 3 of first edition) in biological science (comprising Botany and Zoology) as the total doctrine of external as well as internal relations of shape, comprising not only their simple knowledge, but also their causes and history. According to him (p. 3), investigators who content themselves with simply describing the external and internal shapes, are people rejoicing merely at their beauty, variety aud utility. I cannot see that so wide a scope for the term Morphology is of any use, for the study of the causes of shapes may be safely left to physiology and genetics, whilst on the other hand the simple knowledge of forms will remain necessary for investigations of our kinds.

We may say that Sachs uses the term General Morphology in a sense which is too narrow, whilst Haeckel's conception is vastly too wide, so that the way remains free for the introduction of a term General Morphology in a sense, adapted for indicating a first section of botany to be considered as a foundation for all the rest.

It may now be asked how a General Morphology with its terminology such as needed for phytography and exhibiting the qualities explained above, can be constructed, for I may say at once, that it does not yet exist. The royal highway towards it would be an extensive study of botanical literature, comprising all original papers and books, which might be considered possibly to contain for the first time technical terms of all kinds, organographical as well as anatomical. This procedure would automatically lead to absolute completeness, and terms also, which are not used in the ordinary course of phytography, but belonging to more special investigations or less generally known, would automatically find their place. As examples of this kind I may cite here the terms devised by Mettenius, concerning the distribution of the veinlets in leaf blades of ferns, etc., and in the second place a set of terms, concerning stelar Morphology, to be found in J. C. Schoute, Die Stelär-Theorie, p. 144 footnote.

During some years I made indeed annotations of this kind, when I met in my reading with technical terms, used for the first time. If such a plan could be worked out, there would arise a valuable and complete set of technical terms to be used in phytography and forming a good basis for a General Morphology. The authors of all these terms would be known and in many cases also interesting particulars with respect to the considerations, having led these authors in choosing certain terms. As an instance of what I mean may be cited Nehemiah Grew's term "tissue", so generally used in botany and accepted afterwards as well in Zoology, although expressing only its author's false notion of the internal structure of plant bodies being comparable with a lace-work. Another example is the term "botany" itself, meaning the science of herbs, especially considered as food for cattle.

Obviously the gathering of a complete collection of terms in this way could be a laborious undertaking, and it is to be hoped that some future Oudemans or Daydon Jackson will find leisure to work out such a plan; it will be a useful work, for which many brother-botanists would be grateful. But it did not lay in the line of my mentality, and having many other interests to take care of, I soon felt that an other way must lead me towards the desired end, and it was at once clear, how this could come about.

Writers of text-books and hand-books are of course compelled to do a good deal of work, like that described above and I resolved to make as complete a collection of technical terms as possible by a careful study of some good text-books. Thus I hoped to attain a completeness at least sufficient for the ordinary course of phytography and in this hope I was not deceived.

Chronologically arranged the text-books were those of Oudemans, Sachs, Van Tieghem, Oudemans and De Vries, and Strasburger with his collaborators. I commenced my examination with Strasburger's work — which is much used for it reached in 1928 its seventeenth edition — reading through all parts promising to contain morphological terms. In connection with the fact that an English terminology was needed by me for writing the present work, I made use of an English translation of this text-book 1).

It is clear that the task of collecting technical terms from these text-books was very simple and presented no difficulties at all.

Critical and historical remarks concerning the construction of those text-books have of course no special signification for the art of phytography, so that they will not be made here. They will be met with however by readers interested about things of this kind, in the fifth and last book of the present work.

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1) There have appeared six editions of this translation, the last of them in the year 1930 from the seventeenth German edition. My work mentioned in the text was done however several years ago and I used the third edition of the translation entitled: A Text-book of Botany by Strasburger, Noll, Schenck, and Karsten, revised with the eighth German edition by W. H. Lang, M.B., D.Sc., Lecturer in Botany, University of Glasgow, London 1908. I mention this here, because in a few cases in my synopsis, terms may have been used of which it is desirable to know the origin and then it may be worth while to consult in the first place Strasburger's translation, cited above.

CHAPTER III.

GUIDING SCHEMES IN GENERAL.

Dealing above with the plan of this work I mentioned that the two principal levers used in phytography are General Morphology and Guiding Schemes. The terminology based upon General Morphology is doubtless, from a theoretical point of view, the most interesting of the two. But the use of Guiding Schemes, although exhibiting a more technical character is also very essential and even indispensable. Moreover the use of those schemes may give rise to some controversies and has already done so, so that it is worth while to treat at some length their pros and cons.

A fixed order of sequence of the several subjects and technical terms being absolutely necessary in Linnean descriptions, which often are very long and complicated, obviously the students work could be lightened by the possession of lists containing the order of sequence of the different subjects. Such lists may be called Guiding Schemes and will certainly often have been used by systematical botanists, for facilitating their private work. Years ago I published one in a school-book [1]) for simple organographical descriptions of the higher plants. In the first two editions no such guiding scheme appeared, because I thought that the text of the book itself could be used very well for this purpose. In the preface to the third edition I gave the reasons why a separate guiding scheme is preferable: objections may indeed be raised against the necessity of skimming the whole book for every description, and moreover the wording of the description can with the help of a guiding scheme be brought at once into a much better order of sequence than by using the book itself. This guiding scheme was intended for making a complete description of the organography of the higher plants in all their principal parts. But the present work being of much wider scope than a single school-book and comprising not only the higher plants, but the whole plant kingdom, the number of organographical schemes has been greatly increased rising up to 52. For micrographical purposes I had already published earlier eighteen guiding schemes in a book [2]), destined for university students in their practical exercises. In the work entitled Botanical Pen-portraits [3]) the number of micrographical guiding schemes was augmented to 21, and in the present work the reader will find 28 anatomical schemes.

It is clear that guiding schemes may be a useful help in all phytographical work, for securing the uniformity, indispensable in Linnean descriptions. But if, like in our case, the production of pen-portraits is a principal object, their influence is of still more importance. We have seen that pen-portraits mean the introduction into Linnean descriptions of additions, indeed in telegram-style, but without the use of technical terms. Their purpose is to bring the reader particulars, which have not yet been inserted into our current knowledge, as much as possible things, which nobody had yet mentioned concerning subjects of habitual occurrence. Therefore obviously for making a good pen-portrait, the student's mind ought to be free from the momentary cares, proper to the making of a complicated Linnean description. Perhaps champion chess-players, who can be occupied with twelve games at once, would be able to occupy themselves with new observations, having the guiding scheme for the Linnean description constantly in their mind. But certainly the large majority of botanical students will not possess a psychical capacity, wide enough to give them leisure for original observations with a complete guiding scheme constantly ready in their mind. Experience has indeed shown that most men in order to be really free for letting roam their thoughts, must have a guiding scheme constantly before them to be consulted every moment. Hence for making pen-portraits guiding schemes are indispensable.

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[1]) J. W. Moll, Handboek der Plantbeschrijving, 3 ed., Groningen 1916.

[2]) J. W. Moll, Handboek der botanische Micrographie, Groningen 1907.

[3]) Moll and Janssonius, Botanical Pen-Portraits. The Hague, 1923.

There is still an other point of view from which guiding schemes are of particular value for determining the completeness of descriptions made with their help. If the guiding scheme, which has been used for making a certain description, is known to the reader, he can be sure that all characters, not mentioned in the description, although they appear in the guiding scheme, have been expressly looked for, so that their absence proves that those characters indeed did not appear in the described object. In some cases this knowledge may become essential and an example of this kind concerning the improvement of sugar cane will be afforded in the third book of this work.

Notwithstanding the inestimable value of guiding schemes for phytography in general and especially for the making of pen-portraits, they are at the same time in some respects a weak side of the method they serve. Men older than forty years will be deterred by them, at the best being able of rising to a platonic approbation, and this is very natural. Young students on the contrary evince often a strong prepossession in favour of pen-portraits, so that they willingly accept the use of guiding schemes. When many years ago I introduced the method of pen-portraits and guiding schemes into the practical excercises at the university, many students at the beginning of their studies, in their first or second year, were at once highly interested in the new method, and I found afterwards that several of them profitted by it in their medical studies. On the other hand however some students, by no means constitutionally lazy, decidedly preferred the old method of using a long time for taking the bearings followed by making a drawing, in which often the cells were simply represented by small circles, ellipses, etc., combined with some notes, like name of plant, direction of sections and so forth. Of course students working in this way did not belong to the better sort, but they were very numerous and the better ones could find support only in using books, like Das botanische Praktikum of Strasburger, in which were to be found detailed descriptions of the same objects. Thus the practical exercises became in fact demonstrations belonging to a certain kind of text-book.

It was now however proposed that every student should begin at once with the help of a guiding scheme to make an empirical description, accompanied by a sketch made with the camera lucida. Some students became restive under this demand, sometimes in such a measure that, like restive horses in a manege or circus, they were taken at the allonge. For this purpose student and professor, both provided with sections of the same object, microscope and paper, fell to work together at once with their guiding schemes, the professor putting questions till agreement was reached, and the student had seen what working with the microscope really was. A single lesson of this kind during an hour generally sufficed to bring the restive student to reason for ever.

A very curious example of the irritation, which may be caused by guiding schemes and their use is to be found in a criticism concerning Moll and Janssonius, Botanical Pen-portraits [1]). The use of guiding schemes reminds the critic of Mephisto's advice to the disciple concerning his studies in Goethe's Faust: „Da wird der Geist euch wohl dressiert, in spanische Stiefel eingeschnürt, das er bedachtiger so fortan, hinschleiche die Gedankenbahn und nicht etwa, die Kreuz und Quer, irrlichtelire hin und her," forgetting that our guiding schemes are indeed intended to bind the phytographer to a necessary and wholesome regularity in his work, but at the same time to liberate his mind, so that it gets leisure during his work for fresh observations and new thoughts. Proceeding to give an example of the micrography he chooses stem and leaf of Atropa Belladonna, enumerating the different tissues and in doing this he quite looses his temper and instead of describing their characters he scornfully mentions up to seven times not even the dimensions of the cells, which might at least give a notion of their shape, but only asserts that they have been carefully measured.

On the other hand it seems to me that men of real genius are also apt to be somewhat irritated by guiding schemes. Having a gift of intuition they prefer to go with bold strides towards their goals, thus often reaching them, though for them also regular pen-portraits could be in some cases a valuable help.

The great majority of botanists however are neither men of genius, nor unable to understand the method of pen-portraits, but steady workers, capable of producing with the aid of a good method good scientific work and to them guiding schemes will be a boon, because they will by making good pen-portraits come to interesting results, which otherwise would have been far out of their reach.

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[1]) Zeitschrift für Botanik, 16 Jahrg. 1924. p. 47. Criticism by Prof. G. Karsten.

BOOK II.

SYNOPSIS OF GENERAL MORPHOLOGY.
MORPHOLOGICAL NOTES.
GUIDING SCHEMES.

DIVISION I. SYNOPSIS OF GENERAL MORPHOLOGY.

Some preliminary notices.

It is by no means my purpose to write a more or less complete General Morphology, such as will probably become in future the introductory section of botanical text-books. Readers who wish for particulars on this subject, I referred to the fifth book, Chapter II. The present work however is no text-book, but a manual of phytography, and for this purpose an exact knowledge of heads and parts representing the forms of the whole botanical kingdom is needed, to be used in writing a real General Morphology. Therefore I have chosen for this Division the title of Synopsis. It is actually a collection of about 2500 botanical terms and these have been treated in some 750 articles, each containing a certain number of terms, smaller or larger according to circumstances. Great care had to be taken to assure the knowledge of all connections, which evidently exist between this great number of articles, and in the first place I will explain by what means this was reached. The necessary connections between the articles are formed by means of systems of small formulae exhibiting a progressive or a retrogressive character.

Of the progressive sort there are two kinds. The first of these is very generally used and has the form S. No. X, which means article of Synopsis with the indication of its number. The second progressive formula, which is of much less numerous occurrence is See M. N. No. X, which means See Morphological Note, with the indication of its number, or only M. N. No. X. The reader can find there particulars concerning the same subject, which were considered for some reason as unfit for being mentioned in the articles themselves.

The retrogressive formulae are mostly placed between brackets, and have the following shape: (cf. S. No. X). This means conferatur a lower number of the Synopsis, so that continuity in the retrogressive order is thus warranted.

Experience has shown that the foregoing formulae are amply sufficient links for connecting the articles of the Synopsis.

Some historical remarks with respect to the origin of the Synopsis, will be further necessary. It has been set forth in Book I, Chapter 1: Application of the Linnean method of description to Micrography, how the method of pen-portraits was originally called in the botanical laboratory at Groningen „Micrography" and that it was at first devised as a guidance for medical as well as biological students in their practical exercises with the microscope. Thus at first the method of pen-portraits was strictly confined to anatomical purposes, comprising cytology and histology. But when the first plan of the present work was laid out, I was at once convinced that the Synopsis, which will follow hereafter, could not remain limited to its anatomical contents, but ought to contain as well an organographical part, in which the external differentiation should be treated. At that time however, I thought that for this part of the work it would be sufficient to translate a school-book I had written more than forty years ago, and which was mentioned in Chapter III of the first book, when dealing with the use of guiding schemes on p. 22. This however proved to be a strongly preposterous assumption and the reader needs only to compare the organographical part of the synopsis with the contents of my school-book to see the difference, which however is not only due to the fact that the school-book deals only with the higher plants and the synopsis with the whole plant kingdom, but also the deeper studies concerning the higher plants, conducted especially in directions indicated by Alexander Braun [1]). Therefore it is evident that my school-book, after the publication of this synopsis will want important revisions and will be no longer fit for the use to which it is now put in the botanical laboratories of Groningen and Utrecht.

Another subject to be dealt with in this introduction is:

Combination of organographical and anatomical characteristics in one and the same property. It is obvious that the differences between external organization (organography) and internal organization (anatomy) are not absolute, and even that eventually all properties of one and the same plant will affect one another in some way. On the other hand there is a certain contrast between both phenomena of differentiation, but the ways and the measure in which they cooperate, or are independent of one another, are in most cases unknown and will probably remain so for a long time to come. The consequence of this peculiar relation is that in phytography, organographical and anatomical characters are seldom combined which each other, so that organographical and anatomical descriptions always form two separate sections. Some mixture may however take place in such a manner that certain characters are mentioned as well in the organographical as in the anatomical section. Three cases of this kind are of common occurrence, namely with regard to colours, appendages of the surface and characters of consistency.

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[1]) My Handboek der Plantbeschrijving, the school-book mentioned in the text, appeared in three editions and was intended for use in secondary schools, but the Syllabuses of these schools in our country have become of late been strongly developed, so that certainly no further editions will appear. In the meantime however the book had found its way in the botanical laboratories of Groningen under Prof. Schoute and of Utrecht under Prof. Pulle and was used in both during the practical exercises in organographical botany. As it was no longer to be had however in the book-trade, Prof. Pulle and Prof. Schoute caused a reprint to be made, in several respects altered for laboratory purposes and obtainable at cost price for students in the laboratory. It is entitled: Handleiding bij de Plantbeschrijving, Den Boer, Utrecht. 1929. Not in trade.

Conditions of colour of course are always mentioned in anatomical descriptions of cell walls and cell contents. But the black colour in the cell walls in ebony wood will not be mentioned when organographically describing the trunk of *Diospyros Ebenum,* it will only appear in the description of the anatomy of secondary xylem. In many other cases however the internal colours affect also the external surface, for instance of green foliage leaves, variously coloured petals, etc. See moreover article No. 34 of the synopsis. The green colour exhibits in a high measure, what might be called a double face, the one being its anatomical side, in most cases accompanied by an external appearance, which cannot be passed over in organography. Thus the anatomical side of the green colour in foliage leaves is the fact of its presence in certain organs of the protoplast, called plastids, more numerous towards the upper than towards the lower side; its organographical side is the simple fact of the leaf being green, more intensely on its upper than on its under side.

Appendages of the surface have given rise to a large number of organographical terms, like papillose, pilose, pubescent, etc. etc. surfaces of the most different organs. See article No. 450 of the synopsis.

Characters of consistency have given rise to a few organographical terms, summed up in article No. 35 of the synopsis. The principal of them are herbaceous (comprising succulent) and woody or ligneous. Obviously however these characters will be treated more fully in the anatomical section of the description.

New terms in the Synopsis appearing there for the first time. With respect to these terms, amounting to 48 the reader is referred to the morphological Note No. 31.

Reciprocal relations of pen-portraits and number of technical terms. Concerning the reciprocal relations between the terminological parts of a pen-portrait and its portraying additions in free language, it may be said in general that on one hand the latter tend to delay the premature formation of new technical terms; but that on the other hand, by enlarging our knowledge which becomes more clear and settled, they unquestionably lead to the formation of new technical terms into which they so to say crystallize. For further information about this subject the reader is referred to some observations, which I made in the preface of Moll and Janssonius, Botanical Pen-portraits, 1923, p. 13 and 14.

Receptacle. The term "receptacle" is often used in Botany in its ordinary sense of conceptacle, receiver or reservoir, but in pen-portraits it will be well to avoid its use in this sense as much as possible, because the same term is also used in Botany to designate certain fructifications or parts of them. Six modifications of this kind occur and are in such general use that they cannot be altered without causing a break in the continuity of terminology, prejudicial to the progress of morphology. It will therefore be necessary to distinguish the six kinds of receptacles above alluded to by suitable additions to the term, and so in the Synopsis the following kinds of receptacles have been enumerated: 1. thalloid gemmiferous receptacles (See S. No. 155); 2. thalloid male, and female receptacles (See S. No. 172); 3. cormoid receptacles [1]) (See S. No. 298); 4. floral receptacles (See S. No. 319); 5. common receptacles of the inflorescence (receptaculum commune) (See S. No. 313); 6. receptacle of the sorus (See S. No. 132, 133).

SECTION I. GENERAL PART OF THE SYNOPSIS.

S. No. 1. General plant morphology deals with the several forms shown by the body of a plant in its external as well as in its internal segmentation. It aims at being a foundation for physiological and systematical botany and for plant-geography. Therefore it should start as much as possible from facts and objective views, not from preconceived theoretical ideas.

S. No. 2. By way of introduction the following subjects of general import will be dealt with:
1a. the difference between organography and anatomy See S. No. 3.
1b. organs. See S. No. 4.
1c. individual. See S. No. 7.
1d. natural life-time of individuals. See S. No. 13.
1e. colony. See S. No. 14.
1f. locomotion. See S. No. 15.
1g. habit. See S. No. 16.
1h. polymorphism or pleomorphism. See S. No. 17.
1i. development. See S. No. 27.
1j. symmetry. See S. No. 28.
1k. branching. See S. No. 29.
1l. some general characters and conditions to be used in all morphological descriptions. See S. No. 30.

S. No. 3. (cf. S. No. 2.) General morphology may be divided into:
1a. Organography or external morphology. Treating

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[1]) The sexual cormoid receptacles of *Musci* are often called the flowers of Musci, for instance in Rabenhorst's Kryptogamen-Flora. Schenck in the 3rd English edition 1908 of Strasburger's Text-book of Botany, p. 433, says: "The antheridial and archegonial receptacles are sometimes inappropriately referred to as moss flowers, but they have nothing in common with the true flowers of vascular plants." Although this opinion is certainly expressed too strongly, and although the author himself has modified it in a later edition (Lehrbuch der Botanik, 16 Aufl. 1923 p. 428) and has even suppressed the term "receptacle" altogether, I think nevertheless that he was originally right in proposing it for this case instead of the term "flower". Anyhow this example has been followed in the Synopsis and I trust that botanists will agree with this proceeding.

chiefly of external segmentation; of internal structure only in so far as it is the consequence of folding and connation of external parts, but without reference to cellular structure. See Section II.
1b. Anatomy, phytotomy[1]) or internal morphology. Treating of internal segmentation in so far as it is the consequence of cellular structure. See Section III.

S. No. 4 (cf. S. No. 2). Concerning the term organ the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 5.
1b. homologous and analogous organs. See S. No. 6.

S. No. 5 (cf. S. No. 4). Organs. The body of most, if not all plants exhibits a certain amount of segmentation. The several segments, parts or members into which it is divided, are considered in the present state of science as generally corresponding to distinct, although often imperfectly known functions and therefore they are called organs. Thus it is assumed that the organisation of a plant corresponds to a division of labour or differentiation.

In botany the terms organs, segments, parts or members are however often used promiscuously. Nevertheless the term organ may be used by preference, if it is assumed that something is known about the physiological functions performed by some part. On the other hand the terms segments, parts or members may be preferred if we wish to call special attention to numerical characters and characters of distribution and arrangement, considered more important from a systematical point of view, or if we wish to make our descriptions as objective and as free from thoughts concerning future investigations as possible. This objectivity being of great importance in this book, the terms segments and members will often be used by preference in the synopsis. In anatomy hitherto our knowledge of functions shows often an uncertain and hypothetical character and therefore the term organ in this synopsis will be generally avoided in the part dealing with anatomy, whilst the terms parts, segments or members will be preferred. But in organography (cf. S. No. 3) the functions of many external parts may be considered as well established facts, like reproduction, attachment to the substrate, absorption of nutritive substances, etc. and therefore the term „organ" will be used chiefly in the part dealing with organography.

It is true that the mention of certain functions corresponding to certain organs is for many persons an invitation to speculate, concerning the causes which have led to such a correspondence, often very striking and exhibiting a character of usefulness. Now it is clear that phytography ought to remain free from hypothetical speculations, however plausible, but on the other hand it must be kept in mind that no hypothetical element is present when we simply etablish the facts, that eye and ear are useful to man, that in plants green leaves are useful for carbon-assimilation, roots useful for attachment to the substrate and for absorbing water and soluble substances. Such statements contain nothing but pure and simple facts, without any preconceived idea. Usefulness of organs is certainly of very general occurrence; its existence cannot be accepted without experimental proof and can not be denied simply because we are ignorant concerning its causes. But if on the basis of sound argument we have established the usefulness of an organ, or lack of this quality, we have only stated a fact, which teaches nothing about the origin of that usefulness. If we want to know something of this origin, it will be our task to bring well established facts into harmony with some theoretical or hypothetical conception, like the theory of creation or the theory of evolution and in the latter case with Lamarckism, Darwinism, the hypothesis of teleology (von Baer), "Eigengestaltungstrieb" (Hanstein) "Vervollkommungstrieb", afterwards called "Prinzip der Progression" (Nägeli), entelechy (Driesch), or any other theoretical conception, which might be preferred. But meanwhile there is no reason, why the mention of useful functions should be avoided in phytography in all cases when good experimental evidence is available. Trustworthy facts are necessary for all hypothetical or theoretical conceptions.

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[1]) Haeckel, Generelle Morphologie I, Berlin 1866, p. 4.

During the progressive course of botanical investigation the necessity has been felt for certain terms, designating characters, either more related with functions and almost exclusively used in Physiology, like the external shapes of leaves, stems and roots, or almost exclusively used in Systematic Botany, like those of number, distribution and arrangement. For characters related with functions the term plastic characters has been used, whilst the term plastics of an organ, member, etc. designates the complex of the plastic characters, belonging to such an organ. For characters related with Systematic Botany the term "morphological characters" has often been used, but because this can lead to confusion I introduce here the term organotactical characters, whilst the term organotactics designates the complex of the organotactical characters. These two terms will indeed seldom appear in ordinary Phytography or pen-portraits, but they may be very useful in describing investigations of several kinds. In doing so it should be remembered that we have not to do here with an absolute difference: both terms indicate in fact only that certain characters are almost exclusively used in Physiology, others in Systematic Botany. It is even improbable that there should exist certain characters purely plastic or organotactic and such an assertion would at least be the drawing of a bill of exchange on the results of future researches which probably would not be honoured.

There are many characters which are at once plastic and organotactic, but for this category no special term exists.

See moreover M. N. No. 1 and 2.

S. No. 6 (cf. S. No. 4). With respect to their reciprocal combinations of characters we may distinguish:
1a. homologous organs. They are equal in organotactical characters, but at the same time they are different in plastic characters and functions. Examples are to be found: 1. in organography: scales of buds, foliage leaves, sepals, petals, stamens, carpids, etc. all being metamorphosed phyllomes; neutral spores, microspores, megaspores, pollen-grains and embryo-sacs being all metamorphosed spores (see S. No. 20); 2. in anatomy; thin walled, collenchymatous and sclerenchymatous parenchyma cells; aleurone-, starch-, sugar-, inulin-, tannin-, etc. parenchyma cells; mucilage cells in the tubers of *Orchis* and raphide cells; or mucilage and oil cells in secondary xylem of *Cinnamomum* [1]: *C. parthenoxylon* (oil cells), *C. javanicum* (mucilage cells), *C. Burmanni* (oil- and mucilage cells); phloem and xylem; cortex of stem, mesophyll of leaf and cortex of root; chloroplasts, leucoplasts and chromoplasts.
1b. analogous organs. They are equal in their plastics i.e. their plastic characters and functions, but at the same time they are different in organotactical characters. Examples are to be found: 1. in organography: blade of foliage leaf, phyllodium and phyllocladium; tendrils of *Vitis* and of *Pisum;* roots of *Taeniophyllum* and foliage leaves of other plants; 2. in anatomy: mucilage cells in tubers of *Orchis* (protoplasm) and in leaves of *Malva* (cell-wall); latex cells and latex vessels; exodermis of root and epidermis of stem and leaves; cortex of root and medulla of stem.

The examples cited above, which can be increased at will, show that homologous as well as analogous organs appear both in anatomy and in organography. Nevertheless it is a fact that in organography the phenomenon of homologous organs forms the primary basis of the organographical system, whilst the analogous organs constitute indeed a secondary, yet very important principle of classification. (See S. No. 54). In anatomy on the other hand the terms homologous and analogous organs are scarcely ever used, probably in consequence of the relative uncertainly about the functions of specially differentiated cells and tissues, which as we have seen before leads to a restricted use, almost avoidance of the term organ in anatomy.

See moreover M. N. No. 3.

S. No. 7. (cf. S. No. 2). Concerning the term individual the following subjects will be dealt with:
1a. individual an equivocal term. See S. No. 8.
1b. origin of individuals. See S. No. 9.
1c. degree of individualization. See S. No. 10.
1d. meaning of the term individual. See S. No. 11.
1e. plant-individual. See S. No. 12.

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1) Dr. H. H. Janssonius, Mikrographie des Holzes der auf Java wachsenden Baumarten 9. Lief., Leiden 1928, p. 182, 196, 199.

S. No. 8. (cf. S. No. 7). Individual; an equivocal term. This term, so often used in ordinary life, is a very important one in botanical morphology and cannot be dispensed with in phytography. Nevertheless in consequence of the complicated relations existing in plants, the term has a somewhat equivocal meaning and this point must be established at the very outset. The term designates a single entity or distinct being belonging to a group of beings having so many characters in common that they may be considered as being of the same kind. On the other hand, it is important that vegetable individuals belonging to one and the same group are not really identical: in fact differences are never wanting and if they did not occur the state of individuality would have no interest whatever in morphology and would be rather superfluous in phytography. Thus the term individual implies that a certain entity does belong to a group exhibiting a certain amount of resemblance amongst its members, while at the same time this entity is not identical with all other members of the same group; equality and difference are both at the same time essential characters of individuality and it is but natural that this curious circumstance will give rise to certain difficulties in handling the term. We will see below that in many cases the use of the term individual may even be prohibited in consequence of this ambiguity.

S. No. 9. (cf. S. No. 7). Origin of individuals. Those groups of which the members may be considered as individuals in the vegetable kingdom are the consequence, either of reproduction (being asexual or sexual) or differentiation of the plant-body by division into organs, or in a few cases of symbiosis.

With respect to this different origin we may distinguish:
1a. reproduction-individuals, ordinary individuals, or individuals without any qualification. In the majority of cases they eventually become free and lead a separate life. Individuals being the consequence of symbiosis belong to the same category.
1b. subordinate-individuals or organ-individuals. They are the consequence of differentiation into organs. They do not become free, but remain organically united with one another and do not lead a separate life, although in more exceptional cases, being set free by natural or artificial means they may lead to reproduction and grow out into ordinary individuals.

For examples see S. No. 10.

S. No. 10. (cf. S. No. 7). Degree of individualization. Individuals belonging to the same group may be all of one kind or may be of several different kinds and with respect to this character we may distinguish:
1a. homogeneous individualization. All individuals composing the group are essentially of the same kind so that each individual fairly represents the whole group and may therefore be designated as a complete individual. Examples: Reproduction individuals: *Navicula viridula; Limax* (with hermaphrodite

individuals); Examples Organ-individuals: *Quercus robur,* foliage leaves: *Homo sapiens,* hairs of the head.

1b. heterogeneous individualization. There are two or more subdivisions of individuals, composing the group, so that no single individual fairly represents the whole group; therefore all individuals must be designated as incomplete individuals and the whole group can only be represented by a set of individuals comprising a member of each subdivision. Examples of Reproduction-individuals: *Aspidium Filix mas* (prothallium and sporophyte); *Mankind* (man and woman); *Papilio memnon,* (one male and three female, viz. forma achates, agenor and laomedon); Examples of Organ-individuals: caulomes and phyllomes with as many different incomplete individuals as there are metamorphoses produced by them; *Eucalyptus globulus,* foliage leaves (juvenile and ordinary); *Homo sapiens,* muscular system (more than one hundred various kinds of muscle).

Distribution, arrangement and developmental relations of the incomplete individuals of the two sexes have given rise to a rather large number of special terms and for these the reader is referred to S. No. 21.

S. No. 11. (cf. S. No. 7). Meaning of the term individual. Taking into account what has been said in the preceding articles, it appears that the following characters are of importance for defining the state of individual:

1a. an individual represents the group of which it is a member, either fully (complete individuals) of to a more or less important extent (incomplete individuals).

1b. it is a state of relative independence: an individual being more or less confined and defined from its surroundings and from other individuals; ordinary individuals are without organic coherence with one another, but in organ-individuals it exists.

1c. it has a well-defined beginning and end.

1d. it is a state of relative indivisibility, the parts into which the individual may be divided, losing their identity and no longer representing the group of which the individual is a member.

The phenomena of individualization in the vegetable kingdom in many respects resemble those of the animal kingdom. Nevertheless characteristic differences may be noted, which correspond to fundamental differences in their mode of life. In plants as a rule phenomena of external division have a stronger tendency to expand, so that in heterogeneous individualization of external members a greater number of incomplete ordinary and organ-individuals are formed; the phenomena of internal differentiation on the contrary have a tendency to contract, so that in respect to anatomy a smaller number of incomplete individuals ensues. Moreover all phenomena of individualization in plants exhibit a less closed character. The several organs, external and internal are less sharply differentiated in the performance of their functions. Both ordinary and organ-individuals are more capable of division leading to vegetative reproduction.

S. No. 12. (cf. S. No. 7). Plant-individual.

I. Practical conception. Nearly one hundred years ago Aug. Pyr. de Candolle remarked that the phenomenon of individualization must be seen from two points of view, one theoretical, the other practical and this opinion still holds good. In ordinary life we use the term individual for designating any vegetable being, coherent in its parts and leading a separate life, and often in botany, agriculture, horticulture and arboriculture we are forced to do the same. It is often necessary to express the idea "vague in its origin, but positive in its result", that a tree or a herb is an individual, without being compelled to make out by a preliminary investigation, if we have before us a complete or incomplete individual or perhaps a combination of sporophyte and gametophyte, etc. Hence it is but natural, that in botany a certain number of terms is in use, capable of conveying a notion of the individuality of a vegetable being, together with that of some other characters relating to outward appearance and texture. The principal of those terms are the following:

1a. herb (herba). This term designates a plant consisting of herbaceous, not woody parts. *Senecio vulgaris; Iris pseudacorus;* herbaceous thallomes, like thallus, sporogonium, mycelium, podetium, plasmodium, etc. See S. No. 141, special kinds of thallomes.

1b. tree (arbor), indicated by ♄, the sign of Saturn. This term designates an individual showing a single stock as its basal part, called trunk (see S. No. 181), bearing at its top a crown; either composed of foliage leaves (Tree-Ferns and Palms) or being branched in various ways (trees of *Gymno-* and *Angiospermae)*. They may exhibit large and even gigantic *(Lessonia* and other genera of *Phaeophyceae, Tilia, Eucalyptus, Wellingtonia)* dimensions, but in a few cases they may be small *(Climacium dendroides* [1])). Stock and branches in the higher plants are mostly ligneous [2]) and it may be said that trees, together wit a much smaller number of shrubs, produce all wood used as timber or fuel. Trees generally belong to the group of perennial plants.

1c. shrub (frutex ♄) and fruticose thallome. These terms designate individuals which are always branched without a trunk at the base. *Buxus sempervirens, Ribes rubrum, Chondrus crispus, Cladonia rangiferina.*

II. Theoretical conception. From a more theoretical point of view it seems obvious that the term plant-individual can only designate a single one, being a member of a systematical group, as pure-line, variety, species, genus, family, etc. Further it is clear that such a representation cannot take place by means of a complete set of incomplete individuals representing the systematical group, so that in such cases a plant-individual would be composed of two, three or even four incomplete individuals; it has always been considered an absurdity, that an individual of mankind should consist of husband and wife together. Keeping ourselves on a solid basis of simple fact, we can only say that *Mankind* or *Homo sapiens* is a species, showing heterogeneous individualization, being composed of two kinds of incomplete individuals, called man and woman, both together representing completely the species in its adult state; a single complete Mankind-individual however does not exist. Granting this proposition we find that there is only a relatively restricted number of cases, in which the use of the term plant-individual is permitted. All dioecious plants, for instance, are excluded and plants exhibiting alternation of generations, like the great majority of the vegetable kingdom, are of course in the same condition. The position of the latter is even less favourable, as the consequence of alternation will be a stronger heterogenity of individualization, appearing in a sometimes rather large number of kinds of individuals, constituting the development cycle of most higher plants. The term plant-individual in its only possible conception cannot be used in these cases, without straining ist sense in a very disagreeable theoretical atmosphere, as has been pointed out in the morphological note No. 4.

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[1]) Rabenhorst, Kryptogamen-Flora, Band IV. Laubmoose by Limpricht, III Abth. Leipzig, 1904, p. 35.

[2]) Büsgen, Bau und Leben unserer Waldbäume II ed. Jena, 1917, p. 28, in his definition of a tree cites the ligneous character in the very first place, but this seems to me not advisible.

Taking into account what has been said, we may conclude that only in systematical groups, where homogeneous individualization has taken place, the term plant-individual may be used and that the number of examples to be found in the vegetable kingdom is indeed very small. We may cite: *Schizomycetes,* occurring only as coccus, bacillus, etc.: *Oscillaria* and other *Cyanophyceae; Navicula viridula; Fucus platycarpus* (monoecious); among the higher plants from *Bryinae* and *Pteridophyta* upwards, not a single example exists.

See moreover M. N. No. 4.

S. No. 13. (cf. S. No. 2). Natural life-time of individuals. In this respect the following terms are in use:

1a. concerning ordinary individuals:

2a. annual plants or annuals (planta annua), indicated by the sign of the Sun ☉ or by ①. Plants requiring only the vegetative period within a single year for their complete developmental cycle. *Papaver Rhoeas, Spirogyra.*

2b. biennial plants or biennals (planta biennis), indicated by the sign of Mars ♂ or by one of the following signs ②, ☉ ☉, ☉̈. Plants requiring the vegetative periods of two years for their complete developmental cycle. *Lunaria annua (L. biennis), Beta vulgaris.*

2c. perennial plants or perennials (planta perennis).

Plants lasting a larger number of years and not perishing normally after having once sexually reproduced themselves. [1])

3a. perennial herbs (herba perennis), indicated by the sigh of Jupiter ♃. *Laminaria digitata, Polygonatum officinale, Lamium album.* In higher plants the aerial parts of perennial herbs often perish in the cold or dry season, while the subterrancan parts remain and periodically produce new aerial parts, which may be annual *(Equisetum limosum, Acorus calamus)* or biennial *(Rubus Idaeus).*

3b. trees and shrubs. Confer S. No. 12.

Anabiotic plants is a term used by Alexander Braun for perennial plants in which we see the individuals continually growing out and renewing themselves, their end being always the consequence of external circumstances, so that they show no natural death. *Anemone nemorosa, Convallaria majalis, Tilia* in Neustadt am Kocher (Braun, Pflanzenindividuum, p. 40).

2d. hapaxanth-monocarpic (de Candolle) or haplobiotic (Alex. Braun) plants. Plants having only a single flowering period and perishing at the end of it. *Papaver Rhoeas* (monocyclic); *Beta vulgaris, Verbascum* (dicyclic); *Corypha, Agave, Fourcroya* up to 400 years (polycyclic).

1b. concerning subordinate- or organ-individuals:

2a. caducous organs (caducus). They fall off before or shortly after the complete development of other contemporary parts to which they more or less belong i.e. somewhat prematurely. *Ulmus campestris, Fagus sylvatica,* stipules, falling off before the foliage leaves are full-grown; *Papaver,* sepals, dropping off before expansion of the flower.

2b. deciduous organs. They fall off after the lapse of a season favourable to active vegetation, like a summer or flowering season, mostly thrown off by means of an absciss layer (see S. No. 631). *Aesculus Hippocastanum,* foliage leaves; *Taxodium distichum* and *Populus monilifera,* annual shoots; *Carum carvi,* mericarps; *Salix alba, Alnus glutinosa,* male inflorescences (catkins, see S. No. 308).

2c. persistent organs. They remain during a longer period, often of many years. *Pinus* and *Ilex Aquifolium* and other Evergreens, foliage leaves, *Robinia Pseudacacia,* stipules of foliage leaves; the branches of trees and cormoid rhizomes.

2d. permanent organs. They remain during the whole lifetime of the plant-individual. *Welwitschia mirabilis,* foliage leaves; Tree-Ferns and palms, trunk; *Abies, Acer* and many annual plants, main stem and root.

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[1]) The term polycarpic plants has been used by de Candolle for designating perennial plants flowering repeatedly, like many trees, shrubs and herbs. This term however is superfluous, because according to what has been said about perennials in the text, they necessarily all flower repeatedly if time and circumstances allow it. Therefore the term ought to be abandoned.

S. No. 14. (cf. S. No. 2). Colony. This term is used for any group of ordinary individuals which is separated from other similar groups. The individuals may be more or less independent of one another (many colonies of bacteria cultivated on gelatine, spherical colonies of *Cladophora aegagropila)* or united together by a gelatinous mass produced from their cell walls (zoogloea, *Nostoc pruniforme* or *Leuconostoc)* or associated together after having been originally isolated *(Hydrodictyon,* see S. No. 616) or again they may have taken rise by repeated cell divisions of a single cell *(Pandorina, Volvox, Licmophora flabellata)*. In the latter two cases the colony may equally well be considered as an individual of a higher order and as such may be called coenobium. In consequence of this interpretation the individuals must then be considered as organs of the higher individual and differences between them may ensue *(Volvox)*. See S. No. 145.

S. No. 15. (cf. S. No. 2). Locomotion "Most animals posses locomotion; plants have life, but not locomotion", (Webster's complete English dictionary, sub locomotion) seems to be a self-evident statement and yet it deserves a somewhat detailed consideration. It is certainly true that plants being autotrophous do not need the power of moving towards their nutriment and that the majority of them, especially representing plant-life, are attached by roots, hapteres etc. to substrata of some kind. Animals on the contrary, feeding themselves with other living beings or at least organic substances, must be able to move, often with great velocity in order to procure for themselves the necessary food, and the majority of them leads indeed a free life.

But there is an other reason, why for both plants and animals, moving from place to place is eminently useful, for it procures them the capacity, which they both possess, of dispersing their kind over all habitable surfaces of the earth, and thinking of woods and prairies it is obvious that this capacity shows even a stronger development in the vegetable than in the animal kingdom. It is further clear, that such a dispersal, either of animals or plants cannot take place without the act of moving from place to place, and it seems but natural that animals will generally make use of their active and often strong locomotive power for attaining this purpose as may be attested by the well known migrations of rats and locusts. On the other hand however it is a fact that slow movements may have for this purpose the same usefulness as rapid ones and often may be even more efficient.

Among the higher plants there is yet another necessity for movements in the extraordinary importance of cross fertilisation which is effected by means of migration of pollen on a large scale.

The following kinds of locomotion occur in the vegetable kingdom:
1a. passive movement.

2a. by means of water. *Elodea canadensis* and *Azolla caro-*

liniana, whole plants; *Nemalion* and *Polysiphonia,* conveyance of spermatia towards the trichogyne (see S. No. 123).

2b. by means of air. *Lichenes: Lecanora,* dispersal through the desert *(Manna);* soredia (See S. No. 117) of *Parmelia* and *Roccella; Spinifex squarrosus Linn;* many seeds scattered by wind e.g. *Dipterocarpus Trinervis Blume* and *Fraxinus Ornus;* spores of *Fungi: Cystopus candidus, Bovista;* of many *Bryophyta* and *Pteridophyta,* like *Equisetum;* pollen of *Pinus* and *Alnus glutinosa.*

2c. by means of animals. Pollination by insects, birds, bats and slugs; *Galium Aparine,* dispersal of mericarps.

1b. active locomotion.

2a. by means of growth.

3a. subterranean. Rhizomes, like those of *Equisetum arvense* and many Gramineae.

3b. aerial. *Fragaria vesca, Saxifraga sarmentosa.*

3c. submersed. *Hydrocharis Morsus-ranae, Stratiotes aloides.*

2b. by means of special differentiations. Here we may distinguish:

3a. creeping movements.

4a. amoeboid creeping movements. Consisting of continual changes of the external form of protoplasts. Myxomycetes and many Phycomycetes, the plano- or motile spores (see S. No. 84), appearing during the germination of their aplanospores.

4b. other progressive swinging or creeping movements. *Nostoc; Oscillaria; Beggiatoa; Navicula* and many other Diatomaceae.

3b. free swimming movements, by means of cilia and flagella. They are produced by means of more or less oar-like protoplasmic appendages (cilia) of the outer surface of naked protoplasts. Swarm spores of all kinds, see for examples S. No. 84; spermatozoids, see for examples S. No. 123.

Summarizing the above discussion of our subject we are led to the conclusion that there is indeed a great difference between animals and plants concerning locomotion, but by no means of such a kind, that in the vegetable kingdom it is wholly wanting. The act of moving from place to place plays even in so far a more important part in plants that by it they may accumulate continuously over much larger areas on the surface of the earth than animals (woods, prairies). But the autotrophous nature of plants leads in such cases to a motility less conspicuous than that of animals. In the first place there is only a very small percentage of active locomotion, although a certain power of motility cannot be denied them, but further on they exhibit a profusion of curious differentiations eminently useful for making use of propelling agents. Such agents may indeed have now and then a considerable rapidity. But as a general rule this is of not the case and thus we find that plant locomotion, even that of the active kind is mostly a slow phenomenon. But anyhow it seems clear, that the difference between plants and animals with respect to locomotion has been inadequately expressed in the sentence cited at the head of this article.

S. No. 16. (cf. S. No. 2). Habit. Before embarking on the sea of morphology, where phytography is in command, habit must be mentioned as a pilot who is able in many cases to give phytography a fair start. The term habit, in its proper sense, designates any character or group of characters sufficient for establishing the identity of a plant or one of its parts, if the knowledge of those characters is intuitive and no analysis or description has been made. Hence the knowledge of habit depends more on the investigator's natural aptitude of mind than does the knowledge of the same object, if it has been gained by making a regular description. For the rest cases may occur where no differences of habit seem to appear even to an able observer and where nevertheless the making of a good description brings to light distinct differences.

See moreover M. N. No. 5.

S. No. 17. (cf. S. No. 2). Concerning the term polymorphism or pleomorphism the following subjects will be dealt with:

1a. the meaning of the term. See S. No. 18.
1b. individual and partial polymorphism. See S. No. 19.
1c. important special classes of polymorphism, including alternation of generations. See S. No. 20.

S. No. 18. (cf. S. No. 17). Polymorphism or pleomorphism. This term designates the occurrence of more than one form in a group of individuals or organs exhibiting so many characters in common, that they are considered as belonging to the same kind. With respect to the number of forms appearing we may speak of dimorphism, trimorphism etc. This phenomenon is of most fundamental importance in plants. It is the consequence of all differentiation. At the same time it is the basis of morphology, for the central problem of this discipline is to find points of rest among the ever varying shapes in organography, as well as in anatomy.

S. No. 19. (cf. S. No. 17). With respect to the distribution of the phenomena of polymorphism in plants we may distinguish:

1a. individual polymorphism or individual pleomorphism. It is the occurrence of different reproduction individuals (heterogeneous individualization) in larger or smaller groups of plants.
1b. partial polymorphism or partial pleomorphism. It is the occurrence of different organs considered as belonging to the same kind in one plant-individual.

S. No. 20. (cf. S. No. 17). The following important special classes of polymorphism may be cited here:

1a. general individual polymorphism in the vegetable kingdom and all its subordinate groups. As examples of highly polymorphic groups we may cite: the division of Angiospermae; the families *Orchideae* and *Compositae;* the genera *Hieracium, Rubus;* the species *Taraxacum officinale, Draba verna, Viola tricolor,* etc. (Jordan) and many species of bacteria; the second and further generations after hybridisation.

2a. seasonal dimorphism[1]. The existence of two closely related forms developing in the same locality at different seasons of the year.

1b. modifications or fluctuating variations. They are considered as the consequence of external circumstances or influences and may lead either to individual polymorphism (differences between plants of the same kind raised on the same field or in widely distant stations) or to partial polymorphism (differences between leaves of the same kind, for instance foliage leaves on the same shoot).

1c. mutations. They are considered as the consequence of internal influences and may lead either to individual polymorphism *(Chelidonium laciniatum,* a mutation of *C. majus; Calluna vulgaris,* with white flowers) or to partial polymorphism *(Solanum tuberosum,* bud-variations; *Azalea indica,* with red flowers, producing branches with white flowers).

1d. metamorphism. This term designates homologous organs, exhibiting different functions and plastic characters. Various metamorphoses very often occur on the same plant-individual and the phenomenon then is a kind of partial polymorphism of which the occurrence of scales, foliage leaves, sepals, petals, stamens, carpids etc. on the same plant may serve as an example. But metamorphoses belonging to one and the same set may equally well be distributed over different plant-individuals and for examples the reader is referred to S. No. 21. For metamorphosis of cellular elements see 1h.

As special forms of metamorphosis may be mentioned:

2a. heterophylly. The occurrence of foliage leaves of more than one kind in different zones of the same plant. Submerged and floating or aerial foliage leaves in aquatic plants: *Batrachium, Sagittaria sagittifolia; Platycerium,* mantle-leaves and nest-leaves.

2b. anisophylly. The occurrence of more than one kind of phyllomes intermixed in one and the same zone of the same plant and limited to zygomorphic shoots. *Elatostema, Selaginella, Salvinia.*

3a. amphigastria. This term is used for the members of a ventral orthostichy, consisting of small scale-like phyllomes, while two flank orthostichies are composed of larger leaves. *Frullania Tamarisci.*

2c. juvenile forms of foliage leaves. The occurrence in a younger phase of a plant of foliage leaves which are different from those produced at a later stage, which may be the

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[1] R. von Wettstein. Descendenztheoretische Untersuchungen. I Untersuchungen über den Saison-Dimorphismus im Pflanzenreich. Denkschr. d. Wiener Akad. Bd. 70, 1900.

phase of reproduction. Young plants of scaly-leaved *Conifers* bearing awl-shaped leaves *(Retinospora)*; *Eucalyptus globulus, Ficus repens, Hedera helix* (var. *arborea)*. See S. No. 25 and moreover M. N. No. 6.
1e. the occurrence on a graft-hybrid of branches representing the pure forms of the component plants. *Cytisis Adami* with branches of *C. Laburnum* and *C. purpureus.*
1f. polymorphism in connection with reproduction.

2a. asexual. The occurrence of vegetative and spore producing parts on the same individual, a kind of metamorphosis. *Equisetum arvense* with separate fertile (spore producing) and sterile branches. *Aspidium Filix mas* with separate sporophylls, *Osmunda regalis* with tops of leaves bearing sporangia.

2b. sexual. Besides those cases of sexual polymorphism which may be considered as belonging to metamorphosis, a rather considerable number of terms is in use for indicating presence, distribution and development of the sexual organs. See S. No. 21.
1g. alternation of generations. This term indicates that in a complete developmental cycle there occur two or more different individuals or generations of individuals, arising by means of asexual or sexual reproduction from one another in a regular progressive sequence. This alternation is a phenomenon of the utmost importance in the vegetable kingdom and some special forms of it occur. See S. No. 22.
1h. the endless variety in the development of the cellular elements composing all plants. They form the subject of anatomy in its different branches: cytology and histology.

S. No. 21. (cf. S. No. 20). With respect to distribution, arrangement and developmental relations of the two sexes the following terms are used [1]:
1a. general terms designating only the presence or absence of the two sexes.

2a. bisexual, monoclinous or hermaphrodite. Exhibiting the characters of both sexes together. These terms may be used for ordinary individuals and systematical groups of individuals, like pure lines, varieties, species, genera, etc., or indeed groups of any other kind, but also for organ-individuals, like conceptacles (See S. No. 159), strobili (See S. No. 299) and floral cormi (See S. No. 300), also for sori and hymenia (See S. No. 132). *Oedogonium curvum Prish.,* hermaphrodite individuals and species; *Vaucheria sessilis,* hermaphrodite individuals, species and sori; *Fucus platycarpus,* hermaphrodite individuals, species, conceptacles and hymenium; *Selaginella,* hermaphrodite strobili, sporophyte individuals, species, genus and family, as far as the sporophyte is concerned; *Gentiana,* hermaphrodite floral-cormi, sporophyte individuals, species, genus, family and order, as far as the sporophyte is concerned.

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[1] Knuth. Handbuch der Blüthenbiologie, Leipzig 1898—1905, Band I, p. 33, where also a certain number of terms are to be found which have not been mentioned in the Synopsis, but nevertheless may be useful to students intending to make descriptions suitable for investigations on the biology of flowers; Rabenhorst's Kryptogamenflora IV, 1 Leipzig 1890, Limpricht, Laubmoose, p. 38.

2b. unisexual or diclinous. Exhibiting the characters of one sex only. These terms and their two subdivisions may be used for ordinary individuals, organ-individuals, like conceptacles, strobili and floral-cormi and also for sori, hymenia, sporangia, spores, gametangia and gametes, but not for systematical groups of individuals.

3a. male (for flowers the term staminate may be used).

3b. female (for flowers the term pistillate may be used).

Examples are afforded by: *Oedogonium capillare* and *Vaucheria dichotoma,* male and female individuals; *Fucus vesiculosus,* male and female conceptacles, hymenia and individuals; *Selaginella,* mega- and microsporangia, mega- and microspores and male and female reduced gametophytes; *Mercurialis annua,* male and female sporophylls, floral-cormi, sporophytes and reduced gametophytes; *Gentiana,* male and female sporophylls and reduced gametophytes.

2c. asexual or neutral. Exhibiting no external sexual characters (see S. No. 93). This term is applied only to organs which in allied plants exhibit such characters, like some kinds of haploid spores (neutral in Ferns and Equisetum; mega- and microspores in *Salvinia natans* and *Selaginella)* or the marginal florets of *Centaurea cyanus.*

1b. special terms for designating the distribution of the two sexes in separate ordinary individuals belonging to the same systematical or any other group. They can only be used for such groups, not for individuals, neither ordinary nor organ-individuals. They are:

2a. monoecious. This term designates systematical or other groups of which the ordinary individuals are bisexual, though the sexual organs themselves are not united into hermaphrodite combinations. *Oedogonium* in the section *Euoedogonium,* for instance *Oedogonium curvum* Pringsh.; *Fucus platycarpus; Pinus silvestris,* sporophyte; *Cucurbita pepo,* sporophyte.

2b. dioecious. This term designates systematical or other groups of which the ordinary individuals are unisexual, either male or female. *Oedogonium* in the section *Pringsheimia,* for instance *Oedogonium capillare,* and in the section *Androgyna,* for instance *Oedogonium cyathigerum; Vaucheria dichotoma, Fueus vesiculosus; Cycas revoluta,* sporophyte; *Phoenix dactylifera,* sporophyte.

2c. polygamous. This term designates systematical or other groups which produce not only separate male and female organs, but also hermaphrodite organs, distributed in various ways over one or more ordinary or reproduction-individuals. A very large number of different distributions occur and the principal ones are distinguished by the following special terms:

3a. andromonoecious. Separate hermaphrodite and male organs occur on one and the same individual. *Veratrum; Diospyros virginiana.*

3b. gynomonoecious. Separate hermaphrodite and female organs occur on one and the same individual. *Parietaria officinalis;* many *Compositae.*

3c. trimonoecious or coenomonoecious. Separate hermaphrodite, male and female organs occur on one and the same individual. *Saponaria ocymoides; Gleditschia triacanthos; Aesculus hippocastanum.*

3d. androdioecious. Separate hermaphrodite and male organs occur on two different individuals. *Dryas octopetala.*

3e. gynodioecious. Separate hermaphrodite and female organs occur on two different individuals. *Salvinia pratensis; Knautia arvensis; Myosotis; Thymus.*

3f. trioecious or trioecious-polygamous. Separate hermaphrodite, male and female organs occur on three different individuals. *Fraxinus excelsior; Asparagus officinalis.*

3g. pleogamous. This term designates systematical groups, at the same time both andromonoecious and androdioecious, both gynomonoecious and gynodioecious, or even andromonoecious, androdioecious, gynomonoecious and gynodioecious. Examples are respectively afforded by: 1. *Convolvulus; Ribes Grossularia* and *Saxifraga oppositifolia; 2. Pulsatilla alpina, Dryas octopetala* and *Geum urbanum;* 3. *Euonymus europaeus, Alchemilla vulgaris* and *Valeriana dioica.*

1c. special terms for designating the spatial distribution of sexual organs in hermaphrodite combinations.

2a. dimorphous. There are two kinds of individuals possessing each a special form of flower, both exhibiting sexual organs of different length, so that the stigma in one form is placed on the same level as the anthers in the other; thus two tiers or stories ensue, one for the stigma and one for the anthers in each flower; *Primula acaulis, Hottonia palustris,* species of *Linum;* thus there appear:

3a. longstyled or macrostylous flowers and individuals (macrostylus). Long styles and short stamens.

3b. short-styled or mycrostylous flowers and individuals (macrostylus). Short styles and long stamens.

2b. trimorphous. There are three kinds of individuals, possessing each a special form of flower, all three exhibiting sexual organs of different length, so that three tiers or stories ensue, one for the stigma and two for the anthers in each flower. *Lythrum salicaria, Eichhornia, Pontederia,* species of *Oxalis;* thus there appear:

3a. long-styled or macrostylous flowers and individuals (macrostylus). Long styles; short and intermediate stamens.

3b. mid-styled or mesostylous flowers and individuals (mesostylus). Intermediate styles, short and long stamens.

3c. short-styled or microstylous flowers and individuals (microstylus). Short styles, intermediate and long stamens.

1d. special terms for designating peculiarities concerning the period of maturity of sexual organs in hermaphrodite combinations.

2a. homogamous. Male and female organs come to maturity simultaneously.

2b. dichogamous (dichogamy). Male and female organs do not come to maturity simultaneously. Here we may distinguish:

3a. protandrous or proterandrous (proterandry). The male organs maturing before the female. Most species of *Compositae, Campanulaceae, Umbelliferae,* etc.

3b. protogynous or proterogynous (proterogyny). The female organs maturing before the male. *Scrophularia, Helleborus, Platanus, Aristolochia Clematitis,* many *Gramineae.*

2c. cleistogamous. The sexual organs attain maturity while their enveloping organs remain closed. *Impatiens noli-tangere* and *Viola silvatica* and *canina,* some of the flowers, *Bromis mollis* and *Triodia decumbens* 1).

2d. chasmogamous. The sexual organs attain maturity when the enveloping organs have been opened. *Impatiens noli-tangere* and *Viola silvatica* and *canina,* other flowers.

S. No. 22. (cf. S. No. 20). Concerning the term alternation of generations the following subjects will be dealt with:
1a. meaning of the term. Tendency of individuals to remain united together. See S. No. 23.
1b. autoecious and heteroecious species. See S. No. 24.
1c. absent, simple and antithetic. See S. No. 25.
1d. antithetic alternation of generations: haplobiontic and diplobiontic or Hofmeister's. See S. No. 26.

S. No. 23. (cf. S. No. 22). Alternation of generations. In the present state of botanical morphology this term designates almost exclusively an alternation of reproduction-individuals within the developmental cycle of one and the same plant. We will see below, (see S. No. 25), that such a phenomenon may occur in various forms and it is a curious fact, that nevertheless in the majority of cases the term alternation of generations is used without any further qualification, only for indicating the most complicated form of this alternation, properly to be called antithetic, diplobiontic alternation of generations.

In this synopsis however we will start from another and more

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1) The interesting fact of cleistogamy in the family of *Gramineae* was first observed by Mr. M. Kramer, Professor at an agricultural school in Leeuwarden. He described it in the year 1924 in his work entitled Onze Weidegrassen (Meadow grasses). Maastricht p. 36 and p. 117 for *Bromus mollis.* In the year 1932 he published a more extensive investigation concerning the same fact in *Triodia decumbens* (De bloeiwijzen en het bloeien der weidegrassen. Landbouwkundig Tijdschrift 44ste Jaargang). He mentions that in several Dutch Floras for the determination of indigenous plants, figures of open flowers occur. This is very natural, because those works were written when the cleistogamous character of these flowers was not yet known. For the artist wanting to draw the flower and not finding an open one, it was of course a very simple manipulation to open a flower, before doing his work.

In the Annals of Botany of Vol. 45, 1931, p. 443, Mr. Q. R. Beddows published a paper entitled *Triodia decumbens* Beauv., in which the same fact is described.

general point of view. Firstly the simpler forms of alternation will be dealt with. Secondly, and this is much more important, an alternation of generations consisting not of ordinary-, but of organ-individuals will be introduced and discussed in detail. It has been shown by Alexander Braun in his celebrated treatise "Das Pflanzenindividuum", that in the higher plants there is an order of sequence of different organ-individuals, which will be here designated as "cormus-individuals", exhibiting a certain analogy with the interesting phenomenon in the animal kingdom, called alternation of generations, and this view will be fully adopted and worked out here. The necessary examples of all cases will be brought forward below.

If the alternation of generations is composed of consecutive organ-individuals, as in the case of Alexander Braun, it is obvious, that there exists a permanent organic coherence between the consecutive generations. But if these are formed by reproduction-individuals, there also appears a strong tendency of those individuals to remain united together. Although they certainly often lead an independent existence, yet in other cases the development of the successive individuals takes place on the bodies of the immediately preceding ones, although no real organic union may take place; this relation of one individual being borne by an other may be transitory *(Musci,* protonema, and mossplant), but in some cases permanent (sporogonium). See moreover M. N. No. 7.

S. No. 24. (cf. S. No. 22). When alternation of generation occurs in parasitic species we may distinguish:
1a. autoecious species. The alternating generations appear on the same host. *Aecidium Leguminosarum,* and *Aec. Tragopogonis.*
1b. heteroecious species. The alternating generations appear on different hosts. *Puccinia graminis.* See moreover M. N. No. 7.

S. No. 25. (cf. S. No. 22). In alternation of generations we may distinguish the following cases:
1a. it is absent. *Spirogyra; Oedogonium; Fucus.*
1b. simple alternation of generations. There is only a difference in shape between the several generations. This phenomenon is closely related to metamorphosis, especially to that of juvenile leaves (cf. S. No. 20).

Examples: 1. *Musci,* protonema (see S. No. 148) and mossplant, reproduction-individuals leading a separate life. 2. *Pteridophyta, Gymno-* and *Angiospermae,* suspensor (see S. No. 148) and embryo, reproduction-individuals remaining united together, but the suspensor soon becoming obliterated. 3. *Cladonia,* horizontal primary crustaceous thalli, producing podetia (see S. No. 150), reproduction-individuals leading a separate life. 4. *Ficus repens, Hedera Helix, Eucalyptus globulus, Markgrafia,* vegetative and reproductive organ-individuals organically united together, sometimes afterwards leading a separate life *(Ficus repens, Hedera Helix* var. *arborea).* 5. the order of dif-

ferent cormus-individuals in diplocaulescent, triplocaulescent, etc. cormoid systems. See S. No. 251.
1c. antithetic alternation of generations. The difference of shape, though mostly existing and being very distinct, nevertheless is not of primary importance and in some cases even may be wholly wanting (some diplobiontic *Florideae* with tetraspore plants and gametophytes having the same external shape: *Polysiphonia, Delessaria;* some *Phaeophyceae: Dictyota)*. On the other hand it is chiefly characterised by the occurrence of:

2a. a gametophyte or sexual generation. Sexual organs are produced by it and give rise to the formation of:

2b. a sporophyte, also called asexual or neutral generation. Asexual spores are produced by it and give rise to new gametophytes.

For examples see S. No. 26.

Simple and antithetic alternation of generations may often occur together in the same plant; examples will be cited below.

See moreover M. N. No. 7.

S. No. 26. (cf. S. No. 22). In antithetic alternation of generations with respect to the number of chromosomes in the cell nuclei we may distinguish:
1a. haplobiontic antithetic alternation of generations. The allotypic karokinesis (reduction division) takes place in the zygote, so that gametophyte and sporophyte both are haploid generations. This form of antithetic alternation is of very limited occurrence in the vegetable kingdom. Haplobiontic *Florideae,* like *Batrachospermum moniliforme, Nemalion* and *Scinaia.*
1b. diplobiontic antithetic alternation of generations, Hofmeister's alternation of generations, in the ordinary course of description often called alternation of generations without any qualification. There exists a connection between the alternation of gametophyte and sporophyte on the one hand and that of haploid and diploid generation on the other. The allotypic karyokinesis (reduction division) takes place in a late phase of the development of the sporophyte, so that the gametophyte is a haploid and the sporophyte a diploid generation, though in some cases *(Ascomycetes* and *Basidiomycetes)* there may be a postponed fusion of the sexual nuclei (karyogamy, see S. No. 119). This kind of alternation of generations is of most common occurrence throughout the vegetable kingdom.

Examples, all individuals being reproduction-individuals: diplobiontic *Florideae, Laminaria* (gameto- and sporophyte leading a separate life); *Bryophyta* (sporophyte permanently borne by the gametophyte); *Pteridophyta* (isosporeous: sporophyte at first borne by the gametophyte, soon afterwards leading a separate life; heterosporeous: reduced gametophyte developed on the sporophyte, afterwards thrown off); *Gymno-* and *Angiospermae,* strongly reduced gametophyte developed on the sporophyte, only the male ones being thrown off and transported towards the female ones, which remain on the sporophyte. See moreover M. N. No. 7.

S. No. 27. (cf. S. No. 2). Development. This term is used here in the sense of a passage, exhibited by an ordinary individual, an organ-individual, but also by whole groups of individuals, such as species and higher divisions, towards a more expanded state. It is chiefly characterised by the occurrence of growth and for instance in *Bacteria* and *Saccharomycetes,* this is almost its only and certainly most prominent feature. In higher plants of all kinds however this growth is either accompanied or soon followed by alterations, more conspicuous in a certain sense, which may be considered as phenomena of unfolding and differentiation, leading from an immature young towards a more permanent adult condition, in which individuals and organs may fully perform their functions. Phenomena of this kind appear in all plants and even in all living beings and may be of a very complex nature.

Making use of cinematographic pictures it is at present possible by accelerating or retarding motions, so that they become visible to the human eye, to project on the screen the phenomena of development, so that they may be followed from beginning to end.

In phytography however the only means for describing developmental processes is to make pen-portraits of certain successive phases, which may afterwards be combined in your mind. Among living beings, there may be observed certain differences between development in the animal kingdom and that of plants, although in many respects the developmental phenomena exhibit the same characters in both groups. These differences between animals and plants doubtless exhibit close relationship to the principal differences between both kingdoms. As a general rule it may be said, that plants, being autotrophous and receiving their nutriment from the immediately surrounding soil and air, are incapable of locomotion, while animals are forced continually to move towards the places, where they may find their nutriment. In accordance with these facts we find, that the body of plants is more heavy and clumsy and that the cells most actively entertaining metabolism in their adult state, consist only for a small part of protoplasm and cell wall substance, whilst the greater part of their volume is formed by one or more large vacuoles, filled with an aqueous solution of several substances.

Animal cells on the other hand do not exhibit such vacuoles and in the adult state remain chiefly composed of living protoplasm. In both kingdoms a certain number of cells is used in the formation of skeletons, which in animals give support for their motion and protection for some important organs, whilst in plants they give the necessary supports against the action of gravity and climatological influences, wind, etc.

Corresponding to the above differential characters of plants and animals there may be observed a difference in the modes of development, exhibited by them.

Among the lower plants a certain number, like *Spirogyra* and *Ulva* consist only of cells provided with large vacuoles, and here development of the individuals takes place only by means of continual division and corresponding growth of these cells. In most plants however, and especially in the higher groups from *Bryophyta* and *Pteridophyta* upwards, there appear besides vacuolate mature cells, other cells with small vacuoles and exhibiting so low a grade of differentiation, that they are unable to perform special functions, such as are needed in the higher plants. They are called meristem cells and have a strong tendency to reproduction if only circumstances, such as nutrition, temperature etc. allow of it. Thus, although in some cases they remain dormant, as for instance in certain buds, they show in the greater number of cases, being in action, many cell divisions, so that a meristematic tissue is formed, which under certain circumstances may throw off adult cells, but remains by its repeated cell divisions a continuous source of permanent tissues, during years and even centuries. Thus in many plants, certain organs develop in a way which botanists in speaking of a cell wall would call apposition, new parts being continually added to already existing ones.

In the animal kingdom however no contrast like that between meristematic and permanent cells exists. Cells, possessed of large vacuoles, forming the greater part of their volume, are wanting and excepting cells of the skeleton, adult cells, active in metabolism, chiefly consist of protoplasm. Thus, the animal body is gradually developed from embryonic and nondifferentiated stages in such a manner that the botanist, when speaking of such a growth in cell walls, would call it intussusception. In connection with this peculiar mode of growth, the development of the animal body is mostly restricted to a period of youth, lasting for a shorter or longer time, but passing into a relatively long period of maturity.

In a few cases however the developmental stage in animals seems to be very prolonged, even so that growth is continued as long as life lasts, for instance in pikes, eels, snakes and spp. of *Octopus*, but in none of these cases are new parts added to already existing ones, as in plants; the pike, still growing when a hundred years old, has remained the same animal as it was, when only one year old.

Nevertheless growth of the apposition type may occur in some parts, (skin, hairs, feathers, nails and incisors of Rodents), but in all these cases the contrast between meristem and vacuolate cells, so essential to plants, is totally wanting.

The above considerations tend to show, that in the vegetable kingdom, owing to the occurrence of meristematic tissues, growth may lead to a protracted formation of new parts, much more easily than in animals, where it is restricted to a small number of organs, forming relatively slight portions of the body. But it ought to be kept in mind, that meristem tissues by no means necessitate an appositional growth, although with their help it may play a much more important part than it can do in animals. Indeed we habitually find in plants provided with meristematic tissues a contrast between parts with appositional and intussusceptional growth. As a general rule it may be said that phyllomes, although meristematic in their youth, develop by growth of the intussusception type, call it diffuse growth, so that all parts reach the adult state about simultaneously and then the development is ended. The foliage leaves of *Dicotyledons* afford numerous examples, but at the same time in *Monocotyledons* there may occur, for instance in bulbiferous plants like *Hyacinthus,* exceptional cases where the leaves remain growing by means of a meristem for a rather long time. As another general rule however it may be said that caulomes and roots, often periodically in connection with the seasons of the year, but mostly during their whole life-time, which may last for centuries, continue to grow in length and thickness by means of meristematic, vegetative cones and cambia. Nevertheless here again exceptions may occur, like the receptacles of flowers, exhibiting a limited growth of the intussusception type.

In connection with the peculiar difference between animals and plants there is a difference between these two kingdoms with respect to the dimensions of giant types occurring in both. Giant plants, like the Californian *Wellingtonia,* or Australian *Eucalyptus* exhibit much larger dimensions than giant animals. Elephants and giraffes are truly dwarfs, compared with those large trees, whilst the largest whales hardly have one third of their length and it is clear that the apposition-like development of plants facilitates the development of very large dimensions and a long life-time. From the above considerations it is evident, that the phenomenon of plant development must be fully dealt with in organography as well as in histology.

In organography our attention will be chiefly directed towards the development of plants by means of meristems, in the chapters, dealing with cormus and root.

Alexander Braun's discovery of cormus-individuals, cormoid-systems, cladotaxy, root-individuals, rhizoid systems, rhizotaxy and the general occurrence of the simple alternation of generations in the body of the higher plants, has been based on the knowledge of the meristematic mode of development and is a conception of predominating importance in describing the higher plants. (See for the root S. No. 427 and the morphological note No. 26).

In histology, meristems in their relations with one another and with permanent tissues will also be fully dealt with (See S. No. 618).

See further in the organography S. No. 70 containing terms for the description of early stages in development.

Evidently in describing organs with a strong tendency to appositional growth, the material to be described mostly consists in phases of a continual development and not in wholly adult organs. Hence, the student must continually keep in mind this fact and in the guiding schemes for the description of such organs he will find that it has been fully taken into account.

S. No. 28. (cf. S. No. 2). Symmetry in the sense of a due proportion of the several parts of a body to one another is one of the most important phenomena observable in plants. Asymmetrical[1]) plants (plasmodia of *Myxomycetae)* or external parts are very rare indeed, so that in organography the study of symmetry has always played an important part. In former times, when the study of Botany was chiefly confined to the systematical branch of this science, many illustrious investigators studied the phenomena of symmetry and the reader is referred to the organographical part of this synopsis, where he will find a survey of the principal results of those interesting studies.

Anatomical researches belong to more recent times and hitherto the attention of anatomists has not often been directed towards the phenomena of symmetry, exhibited by cells, vessels and tissues. It is certainly true that in this field symmetry plays a less prominent part than in that of organography, and it would even seem that asymmetrical cells constitute the bulk of many tissues, but be this as it may, it is certainly true, that in anatomical papers mention of symmetry is scarcely ever made, so that this subject has not been dealt with in the anatomical part of the synopsis. Nevertheless it is by no means sure, that this apathy will remain in future and students interested in this direction will no doubt find valuable information on questions of this kind in: F. M. Jaeger, Lectures on the principle of symmetry and its applications in all natural sciences. Amsterdam 1917. See moreover M. N. No. 8.

S. No. 29. (cf. S. No. 2). Branching or ramification. It is clear that this simplest mode of dividing into parts or subdivisions in plants is a phenomenon of most common occurrence. Like symmetry it plays a much more important part in organography than in anatomy. In the latter division of Botany it is relatively seldom described or even mentioned; in the first place, because branching is here often a subordinate phenomenon, in a large measure dependent on the branching exhibited by the external organs of the plant, like roots, caulomes, phyllomes etc. The ramifications of vascular and other bundles in caulomes and phyllomes for instance may serve as examples. The slender veins appearing in unbranched leaves or in unbranched parts of leaves and also the branches in nodes of caulomes, certainly make an exception, but they are not dealt with in the anatomical part of this synopsis. It is true, that branched cellular elements, such as unicellular hairs *(Nymphaea alba,* petiole, internal hairs) or latex fibres of *Euphorbia* are by no means wanting, but their ramification has hitherto not been an object of special anatomical investigation. In organography on the other hand the ramification has been a most important subject of study and a set of terms has been devised which ought to be known to every botanist. For them the student is referred to S. No. 54. See moreover M. N. No. 9.

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[1]) The term asymmetrical flower (See S. No. 378) is used for cases in which the symmetry of the flower has been strongly disturbed *(Valeriana officinalis; Canna indica)*. It is clear that in this term the word is used in another and more restricted sense than in the above text.

S. No. 30. (cf. S. No. 2). A certain number of simple characters and conditions which may be needed in descriptions of objects belonging to the vegetable kingdom, will be dealt with in this general introduction. They are the following:

1a. shape. See S. No. 31.
1b. dimensions. See S. No. 32.
1c. chemical composition. See S. No. 33.
1d. conditions of colour. See S. No. 34.
1e. conditions of consistency. See S. No. 35.
1f. conditions of surface. See S. No. 36.
1g. statistical data. See S. No. 37.

S. No. 31. (cf. S. No. 30). Shape. In describing the shapes of plants and their organs, the student might wish to possess a mathematical formula enabling him to indicate at once the most complicated shape, such as we may for instance meet with in the leaves of ferns and higher plants. As no such formula however has been devised, the student is forced to take another road by dividing and redividing in his mind the complicated organ under consideration into parts of so simple a shape, that they may be indicated by the ordinary terms which are used in solid geometry. The principal bodies of this kind are mentioned here. To them has been added a certain number of terms designating parts constituting them. Thus, if small peculiarities, mostly amounting to mathematical irregularities, are found in botanical vegetable objects, the student will be able to note them in his descriptions in their proper places. The principal terms to be used for this purpose are the following:

1a. polyhedron. Here we may distinguish: 1. Faces. 2. Edges. 3. Vertices.
  2a. regular polyhedra.
    3a. tetrahedron.
    3b. cube.
    3c. octahedron.
  2b. pyramid. Here we may distinguish: 1. Base, 2. Vertex, 3. Vertical or Pyramidal faces, 4. Vertical edges.
    3a. trihedral, tetrahedral up to polyhedral.
    3b. truncated. Here we may distinguish: 1. Bottom surface, 2. Top surface; if the latter are not parallel to one another the term obliquely truncated is used, if parallel that of frustum of a pyramid.
    3c. regular or irregular pyramid.
  2c. prism. Here we may distinguish: 1. Bottom surface, 2. Top surface, 3. Prismatic surfaces, 4. Basal edges, 5. Top edges. 6. Vertical edges.
    3a. bottom- and top surface parallel.
      4a. rectangular.
      4b. oblique.
    3b. bottom- and top surface not parallel: truncated prism.
    3c. number of prismatic surfaces.
      4a. tri- up to polyhedral.

    - 3d. prism with rounded edges.
  - 2d. parallelepiped or paralelepipedon.
    - 3a. rectangular.
    - 3b. oblique.
- 1b. bodies with curved surfaces.
  - 2a. cone. Here we may distinguish: 1. Base. 2. Vertex. 3. Vertical or conical surface.
    - 3a. circular.
      - 4a. right.
      - 4b. oblique.
    - 3b. elliptical.
      - 4a. right.
      - 4b. oblique.
    - 3c. truncated. Here we may distinguish: 1. Bottom surface. 2. Top surface; if the latter two are not parallel to one another the term obliquely truncated is used, if parallel that of frustum of a cone.
  - 2b. cylinder.
    - 3a. of undetermined length.
      - 4a. circular.
      - 4b. elliptical.
      - 4c. cylinder of arbitrary cross section.
    - 3b. of finite length.
      - 4a. circular.
        - 5a. right.
        - 5b. oblique.
      - 4b. elliptical.
        - 5a. right.
        - 5b. oblique.
  - 2c. sphere.
    - 3a. spherical segment. (every part cut off by a flat plane.)
    - 3b. zone of a sphere. (cut out of a sphere by two parallel planes.)
    - 3c. spherical sector. (spherical segment bearing on its base a cone of which the vertex coïncides with the centre of the sphere.)
    - 3d. spherical wedge. (part of a sphere between two planes passing through the centre of the sphere).
  - 2d. ellipsoid.
    - 3a. 3-axial.
    - 3b. of revolution.
      - 4a. prolate.
      - 4b. oblate.

S. No. 32. (cf. S. No. 30). Dimensions. These ought to be mentioned in almost all cases, because they are most important in organography as well as in anatomy from a general point of view. Moreover they have in many cases a special interest, because if given in the three directions of space, they suggest at once to the reader the general shape of the part described. A botanist, respecting himself, and his fellow travellers in the passes of science, will at present apply no other than the French metrical system, now almost universally adopted and he will make use of the following abbreviations:

m = meter; dm = decimeter; cm = centimeter; mm = millimeter; μ = micron, micromillimeter or 0,001 millimeter.

For all dimensions it is of course necessary to mention the directions, in which they have been taken, and in this respect phytography applies the terms used in ordinary life like length, breadth, width, thickness, depth etc.

When however many dimensions are noticed it is necessary to make use of abbreviations, in order to indicate the several directions. In all cases the directions to which these abbreviations refer, should be understood as recorded with respect to the whole organ of which the structure is described, such as stem, root, leaf, etc.

In organography this is evident, but the same rule must be applied also in anatomy. It is by no means exceptional, that the length of a cell does not coincide with that of the whole organ of which it forms a part, and nevertheless it is in all cases most important to know not only the dimensions of the cell itself, but also the directions in which those dimensions extend within the organ. This purpose will be reached, if once for all, also in anatomy, the abbreviations refer not to the cellular elements themselves, but to the organs which they constitute. The above implies however that in a few cases it is impossible to use those abbreviations, viz. when cellular elements are described which are directed in various ways in the same organ, for instance the epithelial cells of spherical or cylindrical schizogenous glands, or wood parenchyma cells extending over the surface of xylem vessels. In these cases no abbreviations can be used and we must return to the ordinary terms: length, depth etc. which this time refer to the dimensions of the cellular elements themselves, and not to those of the organ which contains them.

The following abbreviations are used:

1a. L. = in a longitudinal direction, i.e. in the direction of the longitudinal or main organic axis. (See S. No. 50). This abbreviation is used for organs of all shapes.

1b. Tr. = in a direction perpendicular to the main axis.

2a. For regular cylindrical or prismatical organs without further definition of the direction (caulomes, roots etc.).

2b. For organs with flattened transverse section moreover in a direction perpendicular to the plane of largest transverse extension (phyllomes).

1c. B. = in a direction perpendicular to the main axis and at the same time parallel to the plane of largest transverse extension. This abbreviation is only used for more or less flattened organs, like phyllomes etc.

1d. R. = in a radial direction, i.e. transverse or perpendicular to the main axis and at the same time extending from the centre to the periphery. This abbreviation is only used for cylindrical organs and the like (caulomes, roots).

1e. T. = in a tangential direction, perpendicular to the main axis and

at the same time to the radial direction. This abbreviation is only used for cylindrical organs and the like (caulomes, roots).
1f. H (height) = in a direction perpendicular to the surface of the organ, therefore being different in different parts of the organ. This abbreviation in cylindrical organs coincides with R. and it is only used for organs which are flattened (phyllomes) or exhibit more complex shapes *(Echinocactus)*.
1g. Lev. (level) = in the direction of the surface of the organ. Therefore differing in different parts of the organ. This abbreviation in cylindrical organs coincides with L and T. It is only used for organs which are flattened (phyllomes) or exhibit more complex shapes *(Echinocactus,* stem). In many cases it is moreover necessary to distinguish:

2a. Lev. L. = Lev. and at the same time in the direction of the main axis.

2b. Lev. B. = Lev. and at the same time perpendicular to the main axis.

S. No. 33. (cf. S. No. 30). Chemical composition. Although the chemical composition of plants is a subject of primary importance and biochemical research is full of promise for the future development, especially of Physiology, it is a fact that in the ordinary course of phytography, for which this synopsis is meant as a guide chemical characters are relatively seldom mentioned. In organographical descriptions of multicellular organisms they are only exceptionally noticed, because all essential organs of plants in most cases consist of many well differentiated parts, exhibiting various chemical compositions. In descriptions of cells however we meet with many parts, such as cell walls, starch grains, vacuoles, crystals etc., exhibiting a more or less homogeneous chemical composition.

But here also in the ordinary course of micrography the mention made of chemical composition, necessarily remains restricted and reserved to those particular cases in which the botanical student is at the same time a good chemist and especially interested in solving physiological problems. Thus even in an anatomical description of the ordinary kind the mention of chemical composition remains limited to the results obtained by applying a few generally known reagents to cell walls, starch-grains and so forth.

S. No. 34. (cf. S. No. 30). Conditions of colour. Here for many descriptions the ordinary terms used in daily life for designating colours and their gradations are sufficient. But in other cases more precision is wanted and several systems have been devised for attaining this end. The attention of botanists may be directed here to the following works:

Paul Klincksiek et Th. Valette. Code des couleurs. 720 échantillons de couleurs. Paris, 1908.

Baumans neue Farbentonkarte, System Prase, Aue in Sachsen, 1912 [1]).

In describing plants which exhibit green parts these parts are often by the older botanists considered as colourless, whilst the term coloured (coloratus) is used for all parts not being green, even if they are white.

S. No. 35. (cf. S. No. 30). Condition of consistency. Here the following special terms are in use:

1a. herbaceous (herbaceus). More or less juicy, soft when not turgescent. *Senecio vulgaris*, root, stem, and foliage leaves.

2a. succulent (succosus). Very juicy or fleshy, at least in its inner parts. *Opuntia, Euphorbia resinifera* and *globosa, Mamillaria caespitosa*, stèm; *Richardia aethiopica,* peduncle.

1b. woody or ligneous (ligneus or lignosus). At least for a considerable part hard and relatively dry, not green. *Quercus sessilis* and *Cocos nucifera,* stem.

1c. many terms used in the same sense as in ordinary life, for instance leathery, membraneous, flexible, elastic, etc.

A collection of such terms is to be found in guiding scheme No. 8, under the head: general elementary physical characters.

S. No. 36. (cf. S. No. 30). Conditions of surface. Here many terms used in ordinary life, are applied in their ordinary sense and the collection of such terms is to be found in guiding scheme No. 8, under the heading: surface. But moreover the following cases may be mentioned, in which special phenomena, often of growth, give rise to special conditions of the surface.

1a. as a consequence of secondary growth (see S. No. 627) phenomena occur which affect the condition of the surface in several ways:

2a. by the formation of secondary cork-tissue the surface becomes covered by a layer of dry secondary periderm tissue, often thin (young branches of *Aesculus Hippocastanum)*, in other cases thick and giving in course of time rise to a more or less coarse appearance. *(Ulmus campestris,* var. *suberosa; Quercus suber).*

2b. rhytidoma. (see S. No. 698) is formed in the bark of stems and as the organs grow older this may lead to a squamose structure of the outer surface, a so called scaly-bark; the scales being often thrown off, after a time. Examples are afforded by the stems and roots of many Gymno- and Angiospermous trees, the scales being of very variable dimensions, for instance medium-sized on the stem of *Pinus* and *Acer Pseudo-Platanus* and appearing as large plates on the stem of *Platanus*.

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[1]) Further there may be cited:

Répertoire de couleurs pour aider à la détermination des couleurs des Fleurs, des Feuillages et des Fruits, publié par la Société française des Chrysanthémistes et René Oberthür, avec la collaboration principale de Henri Dauthenay et celle de Julien Mouillefert, C. Harman Payne, Max Leichtlin, N. Severi et Miguel Cortés. Paris, 1905.

Charles Lacouture, Répertoire chromatique, solution raisonnée et pratique des problèmes les plus usuels dans l'étude et l'emploi des couleurs. Paris, 1890.

2c. several organs are dehiscent or are thrown off at a certain period of their life, in consequence of various causes, but always by means of an absciss-tissue (see S. No. 565) and in such cases the ensuing scar is beforehand covered up with a layer of secondary periderm, so that the plant exhibits on those places a surface of a special character. *Aesculus Hippocastanum,* deciduous leaves; *Populus nigra,* deciduous leaves, the scars remaining discernible on stems 20 cm thick; *Ilex Aquifolium,* persistent leaves; *Taxodium distichum,* deciduous cormi of the first year.

2d. lenticels (lenticula). They are due to the formation of secondary cork-tissue and appear as low protuberances scattered over the surface of twigs, thicker branches and thick petioles, performing the function of respiratory apertures; their shapes are simple, circular, or somewhat elongated. Twigs of all shrubs and trees, e.g. *Sambucus nigra;* petioles of *Aesculus Hippocastanum* and *Aralia.*

2e. cork-patches. They are the result of the local formation of secondary cork-tissue on relatively small areas, breaking through the epidermis, so that patches of dry secondary periderm appear on a herbaceous organ. *Eucalyptus globulus,* leaf [1]); *Pyrus Malus,* fruit.

1b. as a consequence of primary growth, appendages of the surface may appear. For the description of these appendages the student is referred to S. No. 447 for organography and to S. No. 738 for anatomy.

1c. as a consequence of wounds the surface may become covered, not beforehand but afterwards:

2a. with wound-cork in the shape of a secondary periderm-tissue. *Solanum tuberosum,* tuber; fleshy fruits of several kinds.

2b. with some more or less protecting substance, like resin, rubber, gum etc. *Pinus sylvestris* wood (resin); *Hevea spp.,* stem and branches (rubber).

It is clear that several of the conditions of surface, cited above, affect more or less the external shape of the organs which are described. Therefore it is a good plan first to describe its general shape without taking into account smaller inequalities due to certain conditions of surface and to be mentioned at the same time with the latter.

S. No. 37. (cf. S. No. 30). Statistical data. Quantitative evaluations of numbers, dimensions, weights, intensity of colour, concentrations of solutions and many other characters must take into account the variability, exhibited by most characters; in other words statistical methods are often needed. In the ordinary course of phytography these methods may be very rough and the investigator will often be contented to choose what seems to him at first sight a mean value or a minimum and maximum value. But in other cases the application of more correct statistical methods is needed and then the following abbreviations [1]) are used: n = number of variates, used for the construction of the frequency curve; M = arithmetic mean [2]); Med = median, dividing the observed variates into two classes of equal frequency; q_1 = lower quartile, dividing the observed variates beneath the median into two classes of equal frequency; Q_1 = lower quartile deviation, obtained by subtraction of the lower quartile from the median value; q_3 = upper quartile, dividing the observed variates above the median into two classes of equal frequency; Q_3 = upper quartile deviation, obtained by subtraction of the median value from the upper quartile; $Q = \frac{Q_1 + Q_3}{2}$ = quartile; min. = minimum of the observed values of the variates; max. = maximum of the observed values of the variates.

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[1]) Moll and Janssonius. Botanical Pen-portraits, The Hague, 1925, p. 171.

Thus for *Solanum tuberosum* the length of the starch grains has been determined as follows: n = 320; Med = 17.75 μ; Q_1 = 7.90 μ; Q_3 = 14.15 μ; Q = 11.025 μ; min. in the class 0—5 μ; max. in the class 80—85 μ. [3]).

It is obvious that from these data a fairly complete representation of the frequency curve may be given and this both in the case of the normal and in that of the skew curve.

The difference between the two quartile deviations indicates the existence of skewness, but is not an exact measure for the degree of skewness.

Compound curves (bimodal up to multimodal) may of course be represented in the same manner, but in these cases only the minimum of the lowest component of the compound curve and the maximum of its upper component is known (see *Amylum Tritici)*.

SECTION II. ORGANOGRAPHY.

CHAPTER I. GENERAL SUBJECTS.

S. No. 38. The principal phenomena, which appear in the development of external organization are the following:

1a. symmetry. See S. No. 39.
1b. division or segmentation of the body into separate parts or subdivisions. See S. No. 54.

§ 1. Symmetry.

S. No. 39. (cf. S. No. 38 and S. No. 28). Concerning the term symmetry the following subjects will be dealt with:

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[1]) They are taken from Johannsen, Elemente der exakten Erblichkeitslehre, 3. Aufl. Jena, 1926.

[2]) In the fourth edition of the Pharmacopoea Neerlandica, where some statistical data appear for the first time in pen-portraits, this value was indicated X.

[3]) Botanical pen-portraits p. 64.

1a. principal kinds of symmetry. See S. No. 40.
1b. symmetry of arrangement: cyclic and spiral. See S. No. 41.
1c. symmetry of shape. See S. No. 49.

S. No. 40. (cf. S. No. 39). Two principal kinds of symmetry may be distinguished.
1a. Symmetry of arrangement. See S. No. 41.
1b. Symmetry of shape. See S. No. 49.

S. No. 41. (cf. S. No. 40). Concerning symmetry of arrangement the following subjects will be dealt with:
1a. general terms used in its description. See S. No. 42.
1b. kinds of symmetry of arrangement. See S. No. 43.

S. No. 42. (cf. S. No. 41). General terms used in the description of symmetry of arrangement are the following:
1a. Orthostichies. The rows of vertically superposed members. Examples are afforded by: *Vicia Faba* and many other plants, in their lateral roots of various orders; *Cereus spp.* Stems with longitudinal ridges; *Lepidocarynae,* scales of fruits *(lorica);* see moreover phyllotaxy, S. No. 255.
1b. Parastichies. All obvious rows of members not being orthostichies. In caulomes with short internodes several of these are more apparent than the genetic spiral, e.g. in the cones of *Pinus*. For the rest genetic spirals are special cases of parastichies.
See moreover S. No. 48.

S. No. 43. (cf. S. No. 41). In symmetry of arrangement we may distinguish the following kinds:
1a. a cyclic or verticillate arrangement. This is an arrangement in whorls, the several parts lying in the same transverse plane.
Juniperus communis and *Elodea canadensis,* foliage leaves; many floral phyllomes. See S. No. 44.
1b. a spiral arrangement. This is an arrangement in spiral series, and a line which may be drawn through the several successive parts is called a genetic spiral. See S. No. 255. *Quercus sessilis,* foliages-leaves; *Nymphaea alba,* stamens. See S. No. 48.

S. No. 44. (cf. S. No. 39). Concerning the term cyclic arrangement the following subjects will be dealt with:
1a. dimerous, trimerous etc. whorls. See S. No. 45.
1b. alternation and superposition. See S. No. 46.
1c. homomerous and heteromerous whorls. See S. No. 47.
1d. a pseudocyclic arrangement. This is an apparent arrangement in whorls, of which it can be proved that it is in reality a spiral arrangement with a strongly depressed genetic spiral.

Examples are afforded by *Lilium martagon* [1]), whorl of foliage leaves at the top of the middle region of the cormus; *Peperomia pulchella* [2]), the phyllomes of the whole vegetative region under and above ground.

S. No. 45. (cf. S. No. 44). In cyclic arrangement we may distinguish with respect to the number of members composing a whorl:
1a. Dimerous whorls. *Aesculus Hippocastanum,* foliage leaves; *Cruciferae,* calyx.
1b. Trimerous whorls. *Elodea canadensis,* foliage leaves; *Gramineae,* stamens.
1c. Tetramerous whorls. *Paris quadrifolia,* floral phyllomes.
1d. Pentamerous whorls. *Rosa gallica,* calyx.
1e. Polymerous whorls. *Equisetum* and *Hippuris vulgaris,* foliage leaves.

S. No. 46. (cf. S. No. 44). In cyclic arrangement we may distinguish with respect to the relative position of the members in successive homomerous whorls:
1a. Alternation. The members of one whorl are placed over the intervals between those of the other. *Linum* and *Galanthus nivalis,* floral phyllomes.
1b. Superposition, opposition or opposite position. The members of the successive whorls are placed vertically one above the other. *Ulmus campestris* and many other *Monochlamydeae,* perigone and stamens; *Archaeocalamites* and *Sphenophyllum,* foliage leaves.

S. No. 47. (cf. S. No. 44). In cyclic arrangement we may distinguish in respect to the number of members in successive whorls:
1a. Homomerous or isomerous whorls. The number of members in the successive whorls remains the same. *Linum usitatissimum,* flowers.
1b. Heteromerous whorls. The numbers of members in successive whorls is not always the same. *Nigella, Compositae* and *Umbelliferae,* flowers; *Peperomia* pulchella, foliage leaves.

S. No. 48. (cf. S. No. 43). Divergence. In spiral arrangement this term is of most general use, and designates the angle between two successive members projected on a horizontal plane; this angle is often indicated as a part of a circle by a fraction, such as 1/2, 2/5 etc.

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[1]) J. C. Schoute. On whorled phyllotaxis I, Growth whorls, Recueil trav. bot. néerlandais, XIX, 1922.

[2]) J. C. Schoute, id. II, Late binding whorls of Peperomia. Rec. trav. bot. néerlandais, XXII, 1925.

S. No. 49. (cf. S. No. 39). Concerning symmetry of shape the following subjects will be dealt with:
1a. polarity. See S. No. 50.
1b. dorsiventrality. See S. No. 51.
1c. actinomorphy. See S. No. 52.
1d. disturbed symmetry. See S. No. 53.

S. No. 50. (cf. S. No. 49). Polarity; a phenomenon comparable to what in crystallography is called hemimorphy. The term polarity implies that there is a peculiar development of form at the opposite ends of an axis or plane. Such an axis is called longitudinal or main axis. We may distinguish:
1a. the polarity of base and apex or unipolarity.
There is a difference of form manifested at both ends of an axis. Base is the extremity of a plant or organ considered as its support and by which in most cases it is attached. Apex is the summit of a plant or organ; it is in most cases free. If locomotion takes place, the base is turned backwards and the apex forwards. The longitudinal or main axis generally coïncides with the largest dimension of the organ, but there are cases, in which it is not actually the longest axis, as may occur in short thick cormi, like those bearing radical leaves *(Beta, Dipsacus,* the stems of young *Palms,* the receptacle of many flowers). This form of polarity is of most general occurrence in the vegetable kingdom, and is manifested in all organs which constitute the higher plants. In many haploid spores of the higher plants, from *Muscineae* upwards, either neutral spores, microspores (and pollen-grains) or megaspores (and embryo-sacs) a distinct polarity appears, and this subject will be dealt with in detail in S. No. 93 and S. No. 94. Plants not exhibiting this polarity are most rare, although they may be found especially among unicellular organisms *(Gloeocapsa)*. The direction of development of plants and their organs may often take place in a certain relation to their polarity of base and apex and then we may distinguish:
2a. acropetal or basifugal succession. Every younger part is nearer to the apex than every older part. Leaves developing from a vegetative cone; lateral roots.
2b. basipetal or acrofugal succession. Every younger part is nearer to the base than every older part. *Hymenophyllum,* sporangia on their columella; *Myriophyllum,* laciniae of leaves; *Gramineae,* longitudinal growth of internodes; *Hyacinthus,* longitudinal growth of leaf.
1b. bipolarity. There are two similar poles each at one of the two ends of the longitudinal or main axis. *(Diatomeae, Desmidiaceae)*. The main axis may be curved *(Closterium moniliferum)*.
1c. dorsiventrality. See S. No. 51.

S. No. 51. (cf. S. No. 49). Dorsiventrality, zygomorphy[1]), or bilateral symmetry. Botanists apply these terms to objects exhibiting not only the polarity of base and apex, but moreover a certain secondary polarity, in a direction perpendicular to the main axis. In these cases there is a peculiar plane, passing through the main axis, which may be called the symmetry plane. Parts or organs lying more or less exactly in this plane, but at opposite sides of the main axis, show different forms and properties; parts at the left and right sides of this plane on the contrary are formed according to the same laws. They are however not congruous, but each others mirror image.

In such a way the symmetry of these plants or organs becomes rather comparable to that of the human body, with its dorsal and ventral, its right and left side. The latter four terms are even often applied to these objects, though of course the indication of a ventral and a dorsal side must be rather arbitrary in most cases.

Examples are afforded by foliage leaves with a well-marked difference between upper and under side *(Aesculus)*, many flowers *(Viola tricolor, Lamium album, Orchideae)* many rhizomes *(Acorus calamus)*, seldom by unicellular organisms *(Rhoicosphenia curvata)*.

S. No. 52. (cf. S. No. 49). Actinomorphy or radial symmetry. These terms are applied in botany to objects exhibiting only a polarity of base and apex, whereas the parts or organs lying in any plane passing through the main axis are formed according to the same laws.

In such cases where the actinomorphous object bears lateral appendages or lateral ornaments, in a limited number, these appendages or ornaments may show a regular distribution around the main axis of the whole organ, so that the main axis becomes comparable to a multiple symmetry axis in the sense of crystallography.

Examples of objects with such a multiple symmetry axis are: with a dimerous axis the thallus of *Fucus* and *Laminaria saccharina,* the calyx of *Cruciferae,* the flower of *Dicentra,* the disciform shoots (without taking into account the spirally arranged phyllomes) of *Opuntia;* in these cases the symmetry reminds one of the rhombic symmetry in crystallography; with a trimerous symmetry axis: *Euphorbia Hermentiana,* stem, *Lilium bulbiferum,* flower; with a tetramerous symmetry axis: *Cereus tetragonus,* stem, *Oenothera Lamarckiana,* flower; with a pentamerous symmetry axis: *Cereus Peruvianus,* stem, *Linum usitatissimum,* flower; with a hexamerous symmetry axis: *Lythrum Salicaria,* perianth and androecium; with a heptamerous symmetry axis: *Trientalis europaea,* perianth and androecium; with an octomerous symmetry axis: *Dryas octopetala,* calyx and corolla; with a polymerous symmetry axis: *Echinocactus Grusoni,* stem, *Sempervivum montanum,* flower.

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[1]) Actinomorphy and zygomorphy are strictly botanical terms, first introduced by Alex. Braun. They were used by Sachs (Lehrbuch 1874 p. 208 and 506), Eichler (Blüthendiagramme 1875) and Goebel (Grundz. d. Systematik 1882 p. 479) and it may be said that they are now generally adopted by botanists. In his well-known paper on *Coelebogyne* (Nova Acta 1859 p. 112) Braun makes mention of zygomorphous in the sense of "eigentümlich unregelmäszig" and this certainly is not in contradiction with the definition given in the text. For the rest we have been unable to find a passage in Braun's works, where the terms were first introduced. Prof. Goebel writes to me that he was not more fortunate and suggests that the terms were introduced by Braun in his lectures, which have not been printed. This supposition certainly is very well founded, because Goebel had good opportunities for knowing something of Alex. Braun's lectures.

Prof. Schoute directed my attention, about ten years after the foregoing part of this note had been written, to a passage in Flora 25, 1842, p. 729, where Hofmeister, in a protocol concerning the botanical section of the twentieth Versammlung deutscher Naturforscher und Aerzte zu Mainz, communicates that Alexander Braun dealt with the symmetry of plant organs and used the term "zygomorphous" for those organs, which can be divided into symmetrical halves, only by a single line. He did not use the term "actinomorphous" here, but called "strahlige Bildung" all cases in which a symmetrical division can take place by more than one line.

S. No. 53. (cf. S. No. 49). Disturbed symmetry. There are some cases exhibiting a more or less exceptional character, which phytographers may describe in different terms according to their mental gifts and the special purposes of the description. They show a very imperfect symmetry, the imperfection sometimes amounting to an almost total absence, but there are indubitable vestiges of symmetry as is shown by comparative morphology, when plants in the same systematical group or organs on the same plant-individual possess a true symmetry of shape, and even the organs with disturbed symmetry during the first stages of development may be symmetrical in optima forma. Therefore such cases are by no means examples of a true asymmetrical texture, but they must rather be considered as parts in which the original symmetry has been disturbed by the intervention of various causes, whose characters in some instances perhaps could be traced. Very interesting examples are the following:
1a. disturbance of dorsiventrality in leaves.

2a. the symmetry of right and left side has been disturbed, but the secondary polarity comparable to dorsal and ventral sides of the human body has been preserved. *Begonia* and *Ulmus campestris,* unequal sided foliage leaves.

2b. the right and left symmetry and the secondary polarity comparable to dorsal and ventral sides of the human body have both been disturbed. *Eucalyptus globulus* of which the juvenile leaves are perfectly dorsiventral, but the much more numerous foliage leaves produced in later developmental stages of the tree are not only unequal sided, but exhibit also a very slight difference between the lower and upper surfaces ¹).
1b. disturbances of dorsiventrality in flowers; so called asymmetrical flowers. Examples are very rare: *Valeriana officinalis; Qualea macropetala; Canna indica.*

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¹) Botanical Pen-portraits. p. 169.

§ 2. Division or segmentation of the body into separate parts or subdivisions.

S. No. 54. (cf. S. No. 38). In the division of the vegetable body two phenomena appear, which often may be blended together, but nevertheless may be clearly distinguished:
1a. ramification or branching. In lower plants there may occur cases of branching, which have not given rise to special botanical terms. On the other hand there exists in botany a rather large set of terms designating various modes of branching, but these are all adapted to organs, exhibiting a symmetry of base and apex and then branching only takes place by means of a more or less lateral (not polar) division or segmentation. This branching is only apparent in the reciprocal spatial relations between the separated parts: number of divisions, reciprocal positions, directions and dimensions, whilst the shapes of the separated parts and their functions are not taken into account. See S. No. 55.
1b. general division or segmentation into different organs. (cf. S. No. 5). This phenomenen is not only apparent in numerical and spatial relations of the separated parts, but moreover their shapes and sometimes also their functions must be taken into account.

In the latter respect it is important to observe at once that some organs exhibit a more vegetative character, whilst others are concerned with reproduction, and that stems, leaves, roots, etc. show a preponderatingly vegetative character, although in more complicated cases they may be indirectly useful for reproduction, but other organs perform functions of reproduction only. See S. No. 68.

S. No. 55. (cf. S. No. 54). Concerning the term ramification the following subjects will be dealt with:
1a. podium and branches or laciniae. See S. No. 56.
1b. terms referring to reciprocal positions. See S. No. 57.
1c. dichotomous (up to polytomous) and monopodial branching. See S. No. 58.
1d. monopodium: racemose and cymose. See S. No. 59.
1e. sympodium. See S. No. 60.
1f. homogeneous and heterogeneous branch-system. See S. No. 64.
1g. adventitious branching. See S. No. 65.
1h. reduction of branch-systems. See S. No. 66.
1i. false branching. See S. No. 67.

S. No. 56. (cf S. No. 55). Ramification or branching. See S. No. 54. In every case of branching we may distinguish:
1a. the podium. It is the basal part or axis which produces the branches.
1b. the branches, laciniae or lobes, the latter terms being used when speaking of flat organs, like leaves. Repeated branching is of the most common occurrence and gives rise to the

formation of branch-systems[1]), a term designating any group of organically connected successive branches, like those forming trees and shrubs.

It is clear that in such cases a branch producing a new branch becomes a podium in its turn. Thus we may often distinguish podia of the first, second, third etc. order; real podia of the first order are for instance in the higher plants only the main stem and the primary root arising from plumule and radicle, but the terms are often used less strictly, so that a podium of a higher order, but being the first of a certain branch-system which is studied, may be considered as belonging to the first order.

If it is desirable to use a more general term we may in the same way speak of axes, laciniae or lobes of the first, second, etc. order. Successive branches are also designated as belonging to the first, second, etc. order, but here it should be kept in mind that a branch of the first order becoming a podium in its turn is thereby elevated to the second order, etc. so that in all cases a podium and branch produced by it, belong both to the same order.

S. No. 57. (cf. S. No. 55). In describing ramifications the following terms referring to reciprocal positions may be used:
1a. median plane. This is the plane passing symmetrically through podium and branch, lacinia or lobe.
1b. lateral plane. This is the plane passing through the longitudinal axis of the branch at right angles to the median plane.
1c. oblique planes. These are all planes passing through the axis of the branch and lying between median and lateral plane.
2a. diagonal planes. These are the oblique planes forming angles of 45° with median and lateral planes.
1d. adaxial, dorsal[2]) or posterior side of the branch. This is the side turned towards the apex of the podium.
1e. anterior, abaxial or ventral side of the branch. This is the side turned to the base of the podium.
1f. right- and left side of the branch. This is what is right and left when the branch is viewed from the ventral side.
1g. axil. This is the angle or corner between the posterior side of the branch and the podium.

S. No. 58. (cf. S. No. 55). With respect to the relations of podium and branches we may distinguish:
1a. cases in which the apex of the podium is transformed into lateral branches, so that no part of it extends beyond the insertion of the

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[1]) H. Marshall Ward, Trees, a handbook of Forest-botany etc. uses this term, for instance in Vol. V., Cambridge 1909, Form and habit, p. 39.

Büsgen, Bau u. Leben unserer Waldbäume 2nd ed. Jena, 1917, p. 27, uses the terms „Sproszwerk" and „Sproszsystem".

[2]) Some authors use the term ventral for what is here called dorsal and vice versa.

branches. The often slightly depressed narrow strip of surface separating the branches is termed saddle and extends downwards to the points where the undivided podium begins.

2a. dichotomous branching, dichotomy or true dichotomy. Two diverging branches are formed at the top of the podium. Repeated dichotomy may take place either in the same plane or in different planes. *Dictyota dichotoma* and *Fucus,* thallus; *Riccia fluitans* and *Marchantia polymorpha,* thallus; *Psilotum triquetrum,* stem; *Lycopodium,* root; *Hyphaene,* stem [1]; *Platycerium alcicorne,* leaf.

2b. trichotomy up to polytomy. Three or more diverging branches are formed. *Selaginella,* stem (tetrachotomy [2])).

1b. monopodial branching, monopodium. The podium more or less continues its apical longitudinal growth and thus a persistent main axis may be distinguished, whilst at a certain distance from the apex more or less diverging lateral branches are formed. For examples see S. No. 59 and S. No. 63.

S. No. 59. (cf. S. No. 55). Among monopodia we may distinguish with respect to the relative development of main and lateral axes:

1a. racemose, botryose, indefinite, indeterminate, or centripetal branching. The podium has a relatively unlimited growth in length, continually producing branches (indefinite or indeterminate), often in a large number; the development of the branches is mostly less strong than that of the podium. The branching process may be reiterated in the same way. Thus the younger branches are nearer to the apex of the podium than the older ones, and considering this apex in a certain sense as the centre we may call the branching system centripetal. *Cladophora, Lejolisia, Stypocaulon* and *Characeae,* thallus; *Frullania, Hypnum* and *Sphagnum,* gametophytes; *Equisetum arvense,* vegetative cormus; the ramification of many trees, either only in the vegetative region *(Aesculus, Acer, Juglans* or continued into the floral region *(Conifers, Betula); Gymno-* and *Angiosperms* roots; the ramification of many Angiospermous phyllomes *(Conium maculatum,* foliage leaves).

Concerning the arrangement of lateral branches we may distinguish:

2a. in cormi:

3a. arrangement in connection with the phyllotaxy of the podia. This is the ordinary case in branched cormi, belonging to the vegetative region. Most Ferns and Gymnosperms; all Angiosperms.

3b. arrangement in connection with the presence of nodi. *Calamites multiramis; Asterocalamites radiatus.*

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[1] J. C. Schoute, Ueber die Verästelung bei monokotylen Bäumen. II. Die Verästelung von Hyphaene. Recueil Trav. bot. néerlandais. Vol. VI. 1909.

[2] Velenovsky, Vergl. Morphol. d. Pfl. I Th. Prag. 1905 p. 260.

3c. arrangement without connection either with phyllotaxy or with the presence of nodi. *Halonia regularis; Bothrodendron minutifolium.*

2b. in roots.

3a. arrangement in orthostichies (see S. No. 42). The number of orthostichies varies according to the order of lateral branches, diminishing with the elevation of the order, in connection with number of the xylem and phloem bundles. See S. No. 728. *Gymno-* and *Angiosperms,* all lateral roots, produced by primary as well as by adventitious roots.

1b. cymose, definite, determinate or centrifugal branching. The podium forms sometimes a single branch, often a small number of diverging branches standing in one another's vicinity, whilst the apical part of the podium above the branching region soon ceases growing and remains relatively short, so that the terms definite and determinate seem adequate; the development of the branches on the contrary is much stronger and the branching process may be repeated in the same way. Thus the younger branches are more distant than the older ones from the centre of the branching system coinciding with the apex of the podium and hence it may be considered as centrifugal.

With respect to the number of branches formed by successive podia we may distinguish:

2a. the monochasium. There is only one branch. *Symphytum officinale,* inflorescence.

2b. the dichasium or false dichotomy. There are two branches. *Radiola Linoides Roth (R. Millegrana)* and *Viscum album,* the whole plant; many inflorescences, like *Fragaria vesca; Amorphophallus bulbosus* and *Helleborus,* the first ramification of the leaf.

2c. the pleiochasium or false polytomy. There are more than two branches. *Euphorbia,* cyathia.

S. No. 60. (cf. S. No. 55). Concerning the term sympodium the following subjects will be dealt with:

1a. meaning of the term. See S. No. 61.

1b. sickle, fan, screw, cincinnus. See S. No. 62.

1c. occurrence of sympodia in various branching systems. See S. No. 63.

S. No. 61. (cf. S. No. 60). Sympodium. There is an apparent main axis, which is in reality composed of successive well-developed bases of podia, extending in prolongation of one another. It is formed by means of displacement in combination with diminished development or even abortion of the apices of successive podia Thus there are formed branching systems often more or less resembling racemose ramifications.

S. No. 62. (cf. S. No. 60). In monopodial sympodia, either racemose or monochasia there is mostly a certain regularity in the reciprocal positions of the successive parts forming a sympodium and then the following cases may be distinguished:

1a. the successive ramifications all take place in the original median plane:

2a. sickle or drepanium. The successive branches all arise on the abaxial side of the respective branches of a lower order. *Juncaceae,* ramifications of the inflorescence; *Amorphophallus bulbosus,* leaf, lateral parts [1]).

2b. fan or rhipidium. The successive branches arise all on the adaxial side of the respective branches of a lower order. Some *Irideae,* ramifications of the inflorescences.

1b. the successive ramifications all take place in the successive lateral planes:

2a. screw or bostryx. The successive branches all arise on the same, either right or left side. *Hemerocallus fulva,* inflorescence.

2b. cincinnus (cicinnus). The successive branches arise alternately on the right and left side. *Symphytum officinale,* inflorescence.

S. No. 63. (cf. S. No. 60). The formation of sympodia may take place in any of the principal branch-systems mentioned above. Thus we may distinguish:

1a. sympodia of dichotomous origin. *Selaginella flabellata,* vegetative region, the successive constituent podia each consisting of many internodia; *Adianthum pedatum,* leaf, branches of the higher orders [2]); *Lycopodium clavatum,* vegetative region.

1b. sympodia of monopodial origin.

2a. sympodia of racemose origin. *Vitis vinifera,* annual shoots composed of the basal parts, formed by one or two internodia of successive podia, each representing an axillary branch of which the apical part is metamorphosed into a tendril or inflorescence; *Tilia, Robinia pseudacacia, Corylus, Ulmus, Betula, Salix,* further *Quercus* and *Fagus Sylvatica* in a certain number of cases, main stem and branches composed of successive annual shoots arising from axillary buds, whilst the apical parts of these annual shoots are lost by abortion or other causes; *Polygonatum multiflorum,* subterranean rhizome composed of successive annual shoots arising from axillary buds, whilst the apical parts of these annual shoots grow out into the aerial parts of the plant (fan [3]); *Orchis Morio,* subterranean parts, composed of only two successive annual shoots at a time, arising from axillary buds, whilst the apical parts of these annual shoots develop into the aerial parts of the plant (sickle [4])).

2b. sympodia of monochasial origin. *Juncaceae,* ramifications of the inflorescence (sickle); *Amorphophallus bulbosus,* leaf, lateral parts

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[1]) Sachs, Lehrbuch. 4. Aufl. p. 187 and fig. 141.

[2]) Sachs, l.c. p. 185 footnote.

[3]) Sachs, Lehrb. 4. Aufl. p. 189.

[4]) Sachs, l.c. p. 187 and fig. 141.

(sickle); some *Irideae,* ramifications of the inflorescences (fan); *Hemerocallis fulva,* inflorescence (screw); *Symphytum officinale,* inflorescence (cincinnus).

S. No. 64. (cf. S. No. 55). When by repeated ramification more or less complicated branch systems are formed, we may distinguish [1]:
1a. homogeneous branch-systems. All parts of the system exhibit the same mode of branching. *Ricciaceae, Coniferae, Radiola Millegrana,* the whole body.
1b. heterogeneous branch-systems. Several parts of the system exhibit different modes of branching.
Aesculus Hippocastanum and many other angiospermous trees, vegetative and reproductive region; many inflorescences, see S. No. 312.

S. No. 65. (cf. S. No. 55). Adventitious branches or branch-systems. These terms are used for ramifications, arising from more or less adult parts and more or less permanent tissues, mostly not in close proximity to a normal meristem and not showing a regular distribution. *Fucus serratus,* young plants growing on the basal part of the thallus; *Pellia epiphylla,* branching of the old thalli; *Zea mais,* roots arising from the stem; *Begonia, Bryophyllum,* young plants on leaves.

S. No. 66. (cf. S. No. 55). Reduction of branch-systems [2]. It is a curious fact, that large branch-systems are apt to become so complicated, that their existence is incompatible with a performance of normal functions. Thus we have found, that in the development of branch-systems often parts of the system may disappear by means of abortion. But there may also take place in the later stage of development a reduction by the loss of certain adult branches. In particular, trees of the Gymnospermous and the Dicotyledonous type, could not exist in their present shape, if they were unable to remove in later phases of their development, branches from an earlier period, and this has been adequately described as „a purifying process". Examples are afforded by many of our trees, where the reduction takes place in consequence of various causes, which it is unnecessary to enumerate here. But two different modes of simplification may be distinguished:
1a. branches are separated from the tree by an absciss-layer, essentially in the same way as the fall of leaves takes place; this absciss-layer may be formed at the base of the branch *(Quercus, Populus),* in other cases at the top of the cataphyllary region *(Salix,*

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[1] Hofmeister. Allg. Morphol. p. 437.

[2] Büsgen, Bau und Leben unserer Waldbäume II. Aufl. Jena, 1917. p. 27 ss., where several other papers are cited.

Prunus padus). Often branches, only one year old are removed *(Populus, Salix)*, but in other cases the deciduous branches may be older, even up to six years; short or dwarf branches are removed more often than elongated ones, but in *Salix* for instance elongated branches are thrown off, whilst *Quercus* throws off branches 0,75 m. long and *Populus canescens* even branches more than 1 m. long. *Populus* often removes branches which are in a dying state. Lateral branches are removed by preference, but in some cases *(Quercus, Tilia)* the shedding of apical branches has also been observed. The removal of branches takes place in our northern temperate climate between the month of July and the autumn; the branches after their removal may contain rather considerable quantities of starch. As further examples for this mode of reduction may be cited: *Pinus, Ulmus, Juglans, Fraxinus*.

1b. branches placed in bad conditions of nutrition, may die and break off without the formation of an absciss-layer. Thus they may disappear altogether, but in other cases *(Quercus, Pinus, Abies)* a basal part some centimeters in length may remain alive and is included in the stem by subsequent growth in thickness of the latter. This mode of throwing off lateral branches is of very common occurrence in woods and materially contributes to the formation of high unbranched cylindrical trunks.

Besides the two modes of reduction described above, it ought to be kept in mind, that many branches may be lost by the attacks of animals and parasitic Fungi, also by unfavourable climatological circumstances, such as excessive cold or heat, wind, snow etc. and further it must be kept in mind, that the branching systems of cultivated trees and shrubs are reduced by means of pruning and lopping. When describing stems of trees, the student must not omit to direct his attention towards possible reductions of all these kinds. On the other hand in describing branch-systems it may be worth while to determine the total length of all branches together, including the podium of the first order.

Concerning roots it has been found that for instance in a strong plant of *Cucurbita Pepo* the total length of all roots may amount to 25 Kilometers.

S. No. 67. (cf. S. No. 55). False branching. This is a phenomenon occurring only in filamentous uniseriate thallomes. There appears a break in the filament and the basal part grows upwards past the apical part; since the latter remains at its original place and also grows in length, the semblance of a branch is formed. *Rivularia bullata, Cladothrix dichotoma.*

S. No. 68. (cf. S. No. 54). Concerning the division into different organs the following subjects will be dealt with:

1a. development. See S. No. 69.
1b. categories of homologous and analogous organs. See S. No. 72.
1c. groups of homologous organs. See S. No. 73.

1d. groups of analogous organs. See S. No. 74.
1e. phenomena disturbing and complicating the division into organs. See S. No. 135.

S. No. 69. (cf. S. No. 68). Concerning the development of organs the following subjects will be dealt with:
1a. terms in use for early stages. See S. No. 70.
1b. exogenous and endogenous development. See S. No. 71.

S. No. 70. (cf. S. No. 27 and 69). Development. For early stages in the development of external organisation, the following terms are in use:
1a. embryo. This terms designates a plant individual in a slightly developed condition, meristematic cells forming either the whole body or at least the most important part of it; differentiation of external shape may be wanting or may have taken place to a certain extent. The following parts may be distinguished:
  2a. the foot. This term designates a mass of tissue, by means of which the embryo remains attached to the parent generation and absorbs nutriment from it. Sometimes it remains in function during the whole life-time of the adult plant, arising from the embryo, for instance in the sporogonium of Mosses (see S. No. 109). In the majority of cases however it is strictly confined to the embryonic stage and disappears soon after this stage has been passed, as for instance in *Filices, Selaginella* and *Salvinia*. In the higher plant it is wanting.
  2b. the hypophysis. This term designates a cell of the embryo, adjoining the suspensor (See S. No. 148) and taking a small part in the formation of the basal portion of the embryo.
1b. bud. This term designates an organ, part or member of a plant in a not completely developed condition, but after a certain differentiation of external shape has already taken place. Buds may subside into a dormant or resting condition, which can last for years and may in many cases be followed again by a period of activity. On the other hand it is a fact that in many cases, for instance in the winterbuds of our trees and in bulbs, there may take place a considerable amount of slow development in a period generally considered as belonging to the dormant state. In fact it is questionable if ever in a dormant bud a true cessation of development occurs. For cormoid buds see S. No. 281.
1c. primordium. This term designates an individual, organ or part in so early a stage of development, that it appears only as a very slight outgrowth without showing traces of external differentiation. Examples are afforded by dormant lateral roots in stems, being slight endogenous protuberances growing out in cuttings; phyllomes in the first stage of their development, being slight external protuberances on the vegetative cone; young embryos in the fertilised ovules of higher plants, still having a globular shape.

S. No. 71. (cf. S. No. 69). The formation of primordia, buds, and embryos may take place by means of:
1a. exogenous development. The primordia arise either from a single superficial cell or from a group containing one or more superficial cells. Examples are the production of phyllomes, appendages of the surface and of most cormi.
1b. endogenous development. The primordia arise from an internal portion of the tissue from which they are derived, so that they are covered by a layer of this same tissue not taking part in their formation. Many trees, adventious lateral branches; most roots.

S. No. 72. (cf. S. No. 68). The organs into which the vegetable body is divided may be distributed over the two categories of homologous and analogous organs, fully dealt with above in S. No. 6, and thus we distinguish:
1a. a homologous category. Organs are placed in this category, if we direct our attention in the first place to organotactical characters, whilst plastic characters, although used in a general way, are considered of secondary importance, and in the latter respect they may be widely different in consequence of metamorphosis. This category is the most comprehensive, because organotactics permit a wider view than plastics can do. Thus it forms the foundation of the organographical system. See S. No. 73.
1b. an analogous category. Organs are placed in this category, if we direct our attention in the first place to plastic characters, while organotactical characters, although used in a general way, are considered of secondary importance. This category is less comprehensive, because plastics permit only a narrower view than organotactics can do. Hence it does not form the foundation of the organographical system, but is only used in constituting subordinate divisions, which however may be of great interest, as for instance vegetative and reproductive organs. In the organographical system they appear in the homologous groups under the heading „special forms", together with other cases which cannot be considered in the light of analogous groups. See S. No. 74.

It is clear that all organs can be placed in both categories, according to the point of view from which they are regarded, but in the two categories they will find different members as their mates. Thus a green foliage leaf if placed in the category of homologous organs, will come together with bracts, pitchers, petals, stamens and all other metamorphoses of phyllomes, while if placed in the category of analogous organs it will find phyllodes, cladodes or green aerial roots as its mates.

S. No. 73. (cf. S. No. 68). With respect to the division into groups of homologous organs we may distinguish:
1a. thallome. (S. No. 140). This term is in the first place used for designating the body of plants, exhibiting no division into organs at all. But there are also many, mostly lower plants, in which such

a division certainly takes place and even to a considerable extent, as in capitate hymenia, but where nevertheless a division so very general and important as that of the higher plants into stem, leaves and root is not attained. For all cases of this kind the term thallome is also used. Such plants however exhibit all kinds of shapes and very different internal structures. The term may be applied equally well to multicellular and to unicellular beings, like *Diatomeae, Desmidiaceae,* etc.

Many plants exhibit in all phases the shape of thallomes (all *Fungi,* even the most highly developed forms, and the majority of *Algae).*

On the other hand in many plants the appearance of a thallome is limited to certain phases of the developmental cycle. Examples of this are afforded by the gametophytes of *Bryophyta* (only the protonema phase), *Pteridophyta* and higher plants.

1b. cormus. (S. No. 174). The body of a plant, or mostly only a part of it, showing differentiation into stem and leaves. These organs may be indicated by the general terms of caulome (stem) and phyllome (leaf). The terms caulome and phyllome are correlative and cannot exist one without the other. Caulome is only the part bearing phyllomes and on the other hand phyllome is only that which is formed at the caulome in a way to be described below [1]).

The following differential diagnoses of the terms may be given:

2a. caulome or stem in the widest sense of the word. It is the part producing phyllomes in acropetal succession; in many cases it is more or less directed upwards; it is strongly branched in the majority of cases and the arrangement of the branches depends usually on that of the phyllomes; it has generally an elongated, cylindrical, prismatical or conical shape but various other shapes are not uncommon, for instance globular and flattened; it is often radially symmetrical, often more or less distinctly dorsiventral; it is divided into nodes (the parts which bear the phyllomes) and internodes (the parts between the nodes); it is as a rule not strongly coloured; it is often herbaceous and often woody; it is often provided with not very abundant stomata; its cortex is mostly not provided with particularly large intercellular spaces; it is permanent, not deciduous, though in some cases small branches may be thrown off by the formation of an absciss layer *(Taxodium distichum, Populus monilifera);* it is mostly monostelous, the stele containing vascular bundles, in relatively rare cases schizostelous *(Ferns)* or without stele (Musci); it often exhibits a relatively thick medulla and a less developed cortex; it is often subsequently more or less thickened by the formation of secondary tissues; it grows at its apex and moreover often shows intercalary growth, for instance in *Gramineae* (see S. No. 621); its growth in length and thickness is often more or less unlimited.

2b. phyllomes or leaves in the widest sense of the word. They are parts produced at the growing apex of caulomes, where they appear in acropetal succession and in a somewhat developed bud-stage (cf. S. No. 70); their growth in length predominates for a time over that of the caulome, so that they arch over the vegetative cone; they show a regular arrangement with respect to one another (phyllotaxy or phyllotaxis, see S. No. 255); ramification of cormi arises by buds generally placed in close proximity to the phyllomes and thus phyllotaxis is a most important factor in the formation of a ramified cormus; they generally do not bear other organs with the exception of appendages of the surface, and certain cases where adventitious buds are formed *(Ferns, Cardamine pratensis, Begonia);* they often are unbranched, but in many cases they may be branched, either more or less superficially by means of laciniae (cf. S. No. 56) or more and often very strongly by means of ordinary branches; they are generally flatly extended plates, the extension being mostly in directions at right angles to the median plane, so that the surface lies more or less horizontal, transversely to the logitudinal axis of the stem, but various other shapes may occur; they are dorsiventral; they are not divided into nodes and internodes; they are strongly coloured; either by means of chloroplasts, chromoplasts or coloured vacuoles; they are herbaceous; they may be caducous and mostly are deciduous by means of the formation of an absciss layer, but in many cases more persistent or even permanent (cf. S. No. 13); they are abundantly provided with stomata which are generally most numerous on the underside; their ground tissue is strongly developed as a mesophyll exhibiting often particularly large intercellular spaces; they are mostly schizostelous, the meristeles often containing only one or a few vascular bundles and no medulla, in relatively rare cases they are partly or entirely monostelous or even without any stelar tissue; secondary tissues are wanting or insignificant; their growth is spread more or less diffusely, sometimes basal or apical; their growth is generally limited, and elongation is not specially favoured, but there are some exceptions *(Lygodium);* they are always of exogenous origin with respect to the caulome which produces them.

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[1]) Sachs, Lehrbuch, 4. Aufl. 1874, p. 153, 160, s. 8.

A cormus is to be found in all higher plants from the *Pteridophyta* upwards; among *Bryophyta* in *Musci* and some of the *Hepaticae;* among *Algae* in *Sargassum* and *Caulerpa.*

1c. root. (S. No. 424). It is an organ which appears only where there is a cormus, though in other cases of this kind it may be absent *(Musci,* gametophyte, *Psilotum,* sporophyte); it generally is directed more or less downwards; it may be unbranched or show any degree of branching and the branches appear in acropetal succession; it does not produce phyllomes, nevertheless adventitious buds are borne by it in some cases *(Robinia pseudacacia);* it generally is provided with a root-cap or calyptra at its apex; it has generally a cylindrical often somewhat more conical shape though other shapes may occur; it is often radially symmetrical, often in its branches slightly dorsiventral; it is not divided into nodes and internodes; it mostly is not strongly coloured; it is often herbaceous, often woody;

it is mostly permanent, but sometimes may be thrown off; its epidermis is mostly provided with numerous root-hairs, but devoid of stomata and is soon thrown off, though in aerial roots sometimes forming a velamen; its cortex mostly forms an exodermis, replacing the epidermis and is not provided with particularly large intercellular spaces; it is monostelous, the stele containing isolated xylem and phloem bundles; it is often subsequently more or less thickened by the formation of secondary tissues; it often exhibits a relatively thick cortex, while a medulla is less developed or even wanting; it grows at its apex; its growth in length and thickness is often more or less unlimited; it has mostly an endogenous origin.

Roots are to be found, with rare exceptions in all higher plants from the *Pteridophyta* upwards.

1d. appendages of the external surface and the surfaces of internal cavities (organum accessorium).

The principal character of these parts is that they show in the great majority of cases no regular arrangement with respect to one another, to be compared with that of phyllomes finding its expression in phyllotaxy; nevertheless a few exceptions occur as in the fruits of *Xanthium* and *Calamus*.

Although they are often scattered over the surface of the parts producing them, yet in other cases their occurrence may be limited to certain regions (hairs on veins of leaves, paraphyses, indusia). They are often unbranched and not seldom branched; their dimensions are mostly small, compared with those of the organs producing them; their external and internal differentiations are very diverse, although generally simple, they often arise in relatively late stages of development, though they sometimes appear on meristematic parts; their growth is generally limited. See S. No. 450, and moreover S. No. 731—738. As examples hairs, prickles etc. may be cited.

It is clear that such appendages, never to be confounded with caulomes, and rather showing some affinity to phyllomes, but separated from the latter by their lack of regular reciprocal arrangement, may be easily distinguished in cormi, because all parts more or less resembling phyllomes, but showing no regular arrangement must be considered as belonging to them. But in thallomes, where the whole body may be formed by a single cell, where the contrast between caulome and phyllome and the regular arrangement of the latter do not exist, it must of course often be difficult to distinguish between ordinary branches and appendages of the surface and we may even say, that from a theoretical point of view such a difference does not exist. Nevertheless in a considerable number of cases thallomes produce parts so very like hairs or other appendages of the surface in cormi, that in the general practice of phytography they are always designated by the same terms used for such organs of cormoid origin.

Concerning roots, the same objections might be raised against the use of the term appendages of their surface. But these objections are less weighty, because true roots are only to be found in plants possessing cormi, so that a comparison with the appendages belonging to the cormus of the same plant is possible.

S. No. 74. (cf. S. No. 68). Concerning the group of analogous organs the following subjects will be dealt with:
1a. enumeration of several groups. See S. No. 75.
1b. the group of reproductive organs, dealt with more in detail and from a general point of view. See S. No. 76.

S. No. 75. (cf. S. No. 74). The groups of analogous organs are very numerous and only a few of them will be mentioned here, their enumeration being limited to those cases which have given rise to the formation of special terms. An attempt will be made to give as complete a list of these terms as possible. Some of them are used in more than one group of homologous organs. We may distinguish:
1a. two groups, together comprising all organs which we may distinguish in organography as well as in anatomy, most organs belonging only to one of these groups [1]). They are:
2a. organs of vegetation. Their function is nutrition in the widest sense of the word, including all phenomena necessary for the life of the individual.
2b. organs of reproduction. Their function is the production of offspring, leading to propagation and multiplication. See S. No. 76.
1b. a group of organs having the function of carbon assimilation. No general term for these organs is in use. The following special terms occur here:
2a. foliage leaves. Metamorphosed phyllomes. See S. No. 224.
2b. phyllodes. Metamorphosed petioles of phyllomes. See S. No. 198.
2c. phylloclades or cladodes. Metamorphosed cormi. See S. No. 278.
2d. green and flattened aerial roots. See S. No. 442.
1c. a group of organs having a special nutritive function, in insectivorous plants. No general term for these organs is in use. The following special terms occur here:
2a. pitchers and utricles. Metamorphosed phyllomes or parts of these. See S. No. 230 and S. No. 231.
1d. a group of organs having the function of attaching plants to their substrate and mostly at the same time of absorbing nutritious substances from it. No general term for these organs is in use. The following special terms occur here:
2a. ordinary roots.

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[1]) In a few cases organs may at the same time be considered as vegetative and reproductive. As an example of this kind the foliage leaves of Aspidium Filix mas., Polypodium vulgare and other Ferns may be cited, which when they are fully developed bear sporangia, whilst at the same time they have the function of carbon assimilation.

2b. hapterae. Organs having the function of anchoring without absording food. Metamorphosed parts of thallomes *(Laminaria, Fucus)*, metamorphosed roots (See S. No. 440), metamorphosed appendages of the surface *(Podostemaceae)*. (See S. No. 450 and S. No. 738).

2c. haustoria or suckers. Organs by means of which parasitic plants penetrate their host-plant. Metamorphosed roots *(Cuscuta, Euphrasia, Thesium,* appendages of the surface in mycelia, *Cystopus candidus, Piptocephalis* and *Tubercinia trientalis)*.

2d. root-hairs, rhizoids and rhizines. Metamorphosed appendages of the surface. See S. No. 450.

1e. a group of organs exclusively belonging to climbing plants (lianes) and capable of attaching them to their supports. No general term for these organs is in use. The following special terms occur here:

2a. organs spirally winding round other objects. Here we may distinguish:

3a. twining organs. Their spiral movements do not take place in consequence of sensitiveness to a touch. Metamorphosed caulomes, phyllomes or parts. See S. No. 177 and S. No. 227.

3b. tendrils. (Cirrus). Their spiral movements take place in consequence of sensitiveness to a touch. Metamorphosed more or less filiform caulomes, phyllomes and parts of the latter or roots. See S. No. 193, S. No. 229 and S. No. 438.

2b. aerial climbing roots. *Hedera Helix; Tecoma radicans; Rhus Toxicodendron.*

2c. adhesive discs. *Ampelopsis hederacea* and *Veitchii,* stem tendrils bearing discs at the tips of their branches; several *Bignoniaceae,* bearing discs at their leaves.

2d. hooks[1]) (unci) and hooklets of various origin. *Uncaria* and *Artabotrys,* metamorphosed petioles of flowers (flowerstalks); *Ancistrocladus,* metamorphosed apices of cormi: Luvunga, metamorphosed dwarfshoots; *Desmoncus,* metamorphosed parts of leaves; *Calamus,* appendages of the surface on leaves; *Rubus caesius,* prickles; *Galium aparine* and *Humulus Lupulus,* trichomes.

1f. a group of organs capable of withstanding the action of injurious influences of the most various kinds and enabling a plant-individual to live through dangerous periods, thus they render possible the existence of perennial plants (see S. No. 13). No general term for these organs is in use. The following special terms occur here:

2a. subterranean parts.

3a. rhizomes or root-stock (rhizoma). They are metamorphosed caulomes or cormi, with but few exceptions horizontally directed and dorsiventral; their basal parts have a tendency to decay and thus their original primary roots are soon lost and replaced by adventitious roots arising from their under sides, often especially from their internodes, or by root-hairs; their internodes are mostly well-developed, often even very long; they are often branched; they produce phyllomes, either in the form of aerial foliage leaves or, mostly, in the form of more or less decaying scale-leaves, which in *Ferns* may be replaced by ramenta; storage of nutritive substances is a function which they perform in many cases. See S. No. 187 and S. No. 279.

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[1]) M. Treub. Ann. du Jard. bot. de Buitenzorg III, 1882, p. 44.

3b. caudex or stock (caudex). They are metamorphosed caulomes. See S. No. 188.

2b. aerial parts.

3a. woody caulomes. Trees and shrubs. See S. No. 12.

3b. succulent caulomes and phyllomes. *Cacti, Euphorbia resinifera* (caulomes); *Mesembryanthemum* (phyllomes).

2c. Submerged parts.

3a. winter buds (hibernaculum), cormoid buds, produced in autumn, which sink to the bottom in winter and rise to the surface in spring to grow out into a new plant *(Hydrocharis Morsus Ranae)*.

1g. a group of organs allied to the preceding one, but performing the special function of storing reserve materials; they are always much thickened [1]). No general term for these organs is in use. The following special terms occur here:

2a. bulbs. The reserve material is chiefly stored in metamorphosed phyllomes, so that bulbs are always metamorphosed cormi.

Bulbils are small bulbs. See S. No. 285.

2b. tubers. The reserve material is not stored in metamorphosed phyllomes. Here we may distinguish:

3a. sclerotia or thalloid tubers. See S. No. 151.

3b. cormoid tubers and root tubers. See S. No. 191 and 444.

1h. a group of more or less conical or cylindrical, more or less woody organs provided with one or more sharp points. No general term for these organs is in use. The following special terms occur here:

2a. spines or thorns (Spina). Metamorphosed cormi, caulomes, phyllomes or roots. See S. No. 439.

2b. prickles. Metamorphosed appendages of the surface. See S. No. 450.

1k. external glands. Organs provided with or wholly consisting of glandular cells. The following special terms occur here:

2a. nectaries. They excrete sugary solutions and may appear as:

3a. floral nectaries. Metamorphosed parts of flowers, phyllomes as well as caulomes or only parts of their surfaces. See S. No. 319.

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[1]) The function of storing reserve material appears more or less distinctly in many other organs of various kinds, often belonging to one of the other groups of analogous organs mentioned here, for instance foliage leaves, ordinary roots, rhizomes, caudices, woody and succulent caulomes; but in none of these cases is the storing of material the primary function and none of these organs is predestined to die, when the reserve materials are used up.

3b. extra-floral nectaries. The same as floral nectaries, but not belonging to the flower. *Prunus laurocerasus,* foliage leaves; *Impatiens noli tangere,* petioles; *Nepenthes,* on the rim of the pitchers; *Acacia pycnantha,* on the phyllodes.

2b. glands excreting digestive fluids in insectivorous plants. Metamorphosed appendages of the surface or simply parts of the surface of phyllomes. *Drosera,* glandular emergences of foliage leaves; *Dionaea muscipula,* glandular hairs on the upper surface of foliage leaves; *Nepenthes,* glands on the inner surface of pitchers.

S. No. 76. The group of reproductive organs, dealt with more in detail and from a general point of view. (cf. S. No. 74). Concerning reproductive organs the following subjects will be dealt with:
1a. asexual and sexual reproduction. See S. No. 77.
1b. primary and secondary reproductive organs. See S. No. 78.
1c. sorus and hymenium. See S. No. 131.

S. No. 77. (cf. S. No. 76). In reproduction we may distinguish:
1a. asexual or vegetative reproduction. Some part of a parent plant grows out into a new plant without any fusion of two parent cells or a previous reduction division taking place. Therefore by this means only the same phase as that in which the parent plant exists at the time of its reproduction can be formed, so that in cases of antithetic diplobiontic alternation of generations a gametophyte can only produce gametophytes as vegetative offspring, a sporophyte only new sporophytes. See S. No. 117.
1b. sexual reproduction. This process begins with the fusion of two parent cells and the product of the fusion grows out into a new plant.

This sexual fusion may however be wanting in a number of cases where it might be supposed to exist. The formation of the sporophyte in Ferns in the ordinary course of development is preceded by a sexual fusion, but in some cases this process may be skipped and sporophytes may appear by vegetative budding on the gametophytes *(Pteris cretica, Nephrodium pseudo-mas* var. *polydactyla)*. In other cases again egg-cells develop without fertilisation and without previous reduction of the number of chromosomes *(Taraxacum officinale, Hieracium, Chara crinita)*. For cases of this kind terms like parthenogesis, apogamy, etc. are used, but they are not morphological terms and therefore will not be dealt with here.

S. No. 78. (cf. S. No. 76). Among reproductive organs we may distinguish:
1a. primary reproductive organs. They are those parts which themselves grow into offspring.

2a. spores. See S. No. 79.

2b. parts of various kind, leading to a purely asexual reproduction. See S. No. 117.

2c. gametes. See S. No. 118.
1b. secondary reproductive organs. They are accessory organs which, though sterile themselves, nevertheless are concerned with reproduction, either sexual or asexual, in some way or other. Here we may distinguish:

2a. organs directly producing spores or gametes. This takes place either by means of cell division or of cell budding, so that they are nearly related to the primary organs and less so to those parts of the plant-body which show a distinctly vegetative character. They mostly exhibit a relatively simple differentiation and slight dimensions, being capsules containing, or branches bearing the primary organs. They appear in the shape of:

3a. conidiophores or sporophores. See S. No. 96.
3b. sporangia. See S. No. 97.
3c. gametophores. See S. No. 125.
3d. gametangia. See S. No. 126.

2b. fructifications. This term designates organs not directly producing spores or gametes, less nearly allied to them and belonging more to the vegetative region of the plant-body. They are parts of this region which have been metamorphosed into organs concerned with reproduction, though often in a rather remote way. This metamorphosis may give rise to very advanced differentiations and may extend over large regions; it may be brought about by changes of shape, like those between the foliaceous thallus of *Himanthalia* and its fruticose fructifications, or in other and more numerous cases not so much by differences of shape, as by a reduction of their nutritive functions, seen in the reproductive branches of *Equisetum arvense;* in all cases, however, where the term fructification is used there is a distinct differentiation between such parts and the truly vegetative region of the plant-body. They appear in a great variety of special forms. Besides the examples cited above the following may be given: *Tetraphis pellucida;* gemma-cups; *Marchantia polymorpha,* male and female receptacles; *Aspidium Filix mas,* fertile leaves, green and producing sori; *Osmunda regalis,* fertile leaves, of which the apical part has lost its green colour and is covered with sporangia; *Ophioglossum* and *Botrychium,* fertile leaves, divided into a green segment and another covered with sporangia; *Blechnum Spicant,* fertile leaves, without any green parts; *Florideae,* cystocarps; *Ascomycetea,* apothecia and perithecia; all kinds of mushrooms; the flowers and even inflorescences of higher plants. See S. 152, 194, 232, 235, 296 and moreover M. N. No. 10 and 11.

S. No. 79. (Cf. S. No. 78). Concerning spores the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 80.
1b. naked and walled spores. See S. No. 81.
1c. haploid, diploid etc. spores. See S. No. 82.
1d. endospores and ectospores. See S. No. 83.

1e. planospores (including swarm-spores) and aplanospores. See S. No. 84.
1f. conidia (including basidiospores). See S. No. 85.
1g. chlamydospores (including smut-spores and oidia). See S. No. 86.
1h. sporidia and resting spores. See S. No. 87.
1i. summer and winter spores. See S. No. 88.
1j. tetraspores. See S. No. 89.
1k. auxospores. See S. No. 90.
1l. asexual spores and spores related with sexual reproduction. See S. No. 91.
1m. spores related with sexual reproduction; the result of a sexual fusion or of sexual fusion combined with cell divisions. See S. No. 92.
1n. spores the result of a reduction division: male and female spores. See S. No. 93.
1o. polarity of base and apex in spores. See S. No. 94.
1p. pycnospores. See S. No. 95.

S. No. 80. (cf. S. No. 79). Spores (sporae). This is a comprehensive term for designating relatively small bodies of very different kinds, but all capable of direct development into plant individuals or certain of their phases; they are unicellular in the great majority of cases, but in some instances they may be pluricellular *(Geoglossum diforme, Pleospora* and *Anaptychia ciliaris,* ascospores; *Phragmidium subcorticium,* teleutospores; *Nectria galligena,* conidia) or they may have a tendency to aggregate into clusters (massulae, see S. No. 104); their shapes are of very different kinds: spherical, ellipsoidal, rod-shaped, tetrahedral, filiform, etc.; they may be naked motile protoplasts or non-motile and invested with a cell wall which often exhibits an external layer of cutin (see S. No. 522); they are mostly set free when ripe and thus may be dispersed, though in other cases they may remain in the sporangia in which they were formed *(Azolla,* microspores, macrospores of higher plants); they may be colourless, but are often coloured in very different ways by pigments either in the cell wall or in the cell contents; they may be purely asexual, but on the other hand may have connections of different kinds with sexual reproduction.

S. No. 81. (cf. S. No. 79). With respect to the occurrence of a cell wall we may distinguish:
1a. naked spores. They possess no cell wall. All swarm-spores (see S. No. 84); tetraspores (see S. No. 89).
1b. walled spores. They are invested with a cell wall. *Fungi,* conidia; *Pteridophyta,* spores.

S. No. 82. (cf. S. No. 79). With respect to the number of chromosomes contained in their cell nuclei we may distinguish:
1a. haploid spores. They contain only a single set of chromosomes: see further S. No. 483 and S. No. 26. Spores of *Muscineae*

and *Pteridophyta;* pollen and embryosac of *Gymno-* and *Angiospermae.*
1b. diploid spores. They contain two sets of chromosomes; see for the rest S. No. 483 and S. No. 26. *Spirogyra,* zygospores; *Oedogonium,* oospore.
1c. triploid, tetraploid spores. They may occur in exceptional cases. See S. No. 483 and S. No. 26.

S. No. 83. (cf. S. No. 79). With respect to their mode of origin we may distinguish:
1a. endospores. They are inclosed by the cell walls of their parent cells or by sporangia of any kind; they may be naked or walled spores. See S. No. 84 and S. No. 89.
1b. ectospores or exospores. They are not inclosed by the cell walls of their parent cells or by sporangia of any kind; they are all walled spores and arise either by cell division or by cell budding. See S. No. 84 and S. No. 85.

S. No. 84. (cf. S. No. 79). With respect to the power of motility we may distinguish:
1a. planospores or motile spores. They are capable of locomotion either by amoeboid (Myxomycetae, initial stage of germination [1]) or by swimming movements (see S. No. 142). They are naked endospores, leaving their cell walls or sporangia when they have attained a mature state.

2a. swarm-spores or zoospores. They are capable of swimming movements and exhibit flagella or cilia (see S. No. 142), different in number and arrangement; when they are set free they mostly become egg-shaped; they are often provided with one or more plastids (see S. No. 489), with a coloured eye-spot or stigma (see S. No. 142) and a contractile vacuole (see S. No. 508): they are often asexual, but in other cases they are sexual, so that they may be considered as gametes and frequently both asexual and sexual swarm-spores may be produced by the same individual *(Ulothrix zonata,* asexual and sexual swarm-spores; *Oedogonium,* asexual and male swarm-spores; *Saprolegnia,* asexual swarm-spores).

The term androspores designates a special kind of swarm-spores giving rise to the formation of dwarf males as in *Oedogonium ciliatum* (see S. No. 128).
1b. aplanospores or non-motile spores. They are incapable of locomotion; they may be either endo- or ectospores, walled or naked spores *(Dictyota,* tetraspores); they are often asexual, though they may have connections of more than one kind with sexual reproduction. Aplanospores of different kinds may be produced by the same plant individuals *(Puccinia graminis* with uredo-, puccinia- and aecidiumspores; *Mucor Mucedo* with zygospores and asexual endospores; etc.).

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[1]) A. Lister, A monograph of the Mycetozoa, London 1894. p. 3.

S. No. 85. (cf. S. No. 79). Conidia. They are walled ectospores which are set free by abstriction; they are often formed by cell budding; they may be single (uredospores) and in a few cases they may be pluricellular *(Puccinia phragmidium)*, often also they appear in shorter or longer chains formed by cell divisions in basipetal order *(Penicillium crustaceum, Aspergillus (Eurotium) herbariorum);* they are often formed on special organs called conidiophores (see S. No. 96). The term basidiospores designates conidia which are produced by a special kind of conidiophores called basidia (see S. No. 96 and for the rest S. No. 130). *Psalliota campestris.*

S. No. 86. (cf. S. No. 79). Chlamydospores. This term designates spores having a wall, generally thick and spores originating directly from cellular elements of the vegetative body, preceded by cell division, often with subsequent rounding off and ultimate separation. *Ustilagineae, Nostoc paludosum* and *Rivularia Sprengeliana* [1]). Chlamydospores may be terminal or intercalary, according to their occurrence at the ends or in the middle parts of the cellular elements by which they are produced; *Fusarium Solani* exhibits both kinds at the same time.

The term smut-spores or brand-spores designates darkly coloured resting chlamydospores. *Tilletia Tritici.*

The term oidia is used for chlamydospores which remain thin-walled and are not or only very lightly rounded off before separating. *Oidium lactis.*

S. No. 87. (cf. S. No. 79). With respect to duration we may distinguish as two extreme cases:

1a. sporidia. They are spores exhibiting a more or less provisional character; they have thin walls and germinate soon after their formation. *Puccinia graminis,* spores produced by the promycelium (see S. No. 148) arising from the puccinia spores; *Ustilago Tritici.*

1b. resting spores or hypnospores. They are capable of withstanding injurious influences of temperature, drought time, etc. and often remain dormant for some time before germinating; they are always walled spores and the walls may be often very thick; they may be endo- as well as ectospores, also chlamydospores, smut-spores, zygo- and oospores. *Bacillus subtilis* (endospores), *Ustilago Maydis* (smut-spores, at the same time ectospores), *Nostoc Paludosum* and *Rivularia Sprengeliana* (chlamydospores); *Mucor* (zygospores); *Vaucheria* and *Oedogonium* (oospores).

S. No. 88. (cf. S. No. 79). With respect to the season of the year in which they principally appear we may distinguish:

1a. summer spores. They are unicellular conidia, arising singly at the top of short conidiophores and they generally develop

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[1]) Frank, Lehrb. d. Botanik. Band II, Leipzig 1893, p. 66. fig. 284.

in the earlier part of the summer season. *Puccinia graminis*, uredospores.
1b. winter or teleutospores. They are conidia, consisting of one or more cells, having the character of resting spores (cf S. No. 87) and forming short chains at the top of short conidiophores; they generally develop in the later part of the summer season and persist through the winter. *Puccinia graminis*, pucciniaspores; *Phragmidium violaceum*, phragmidiumspores.
Summer and winter spores often appear in groups which may be called sori (see S. No. 132).

S. No. 98. (cf. S. No. 79). Tetraspores. They are naked and haploid endospores, usually produced in groups of four, and each of these groups is contained in a sporangial cell belonging to a thallus and often embedded in it. *Callithamnion corymbosum; Dictyola dichotoma.*

S. No. 90. (cf. S. No. 79). Auxospores. This term designates a special kind of spores which are considerably larger than the cells by which they are produced, after the protoplasts have left their cell walls; they may be the product of a sexual fusion and in fact often may be considered as zygospores (see S. No. 92; *Navicula viridula)*, but in other cases they are asexual and may arise in combination with cell division *(Synedra, Rhabdonema)* or even without it by the enlargement of the protoplast of a single cell *(Melosira)*.

S. No. 91. (cf. S. No. 79). With respect to the relations between spores and sexual reproduction we may distinguish:
1a. asexual or vegetative spores. There is no direct relation between spores and sexual reproduction. Confer moreover S. No. 77. *Penicillium glaucum*, ectoconidia; *Puccinia graminis*, uredospores.
1b. there is a more or less close relation between spores and sexual reproduction and this may be of different kinds.
2a. the spores are the result of a sexual fusion. See S. No. 92 and S. No. 130.
2b. the spores are the result of cell divisions which are accompanied by an allotypic karyokinesis (reduction division); they always produce a sexual generation. *Spirogyra*, zygospores; *Oedogonium*, swarm-spores arising from the oospore. When Hofmeister's alternation of generations occurs, these spores appear at the close of the asexual generation, as in *Bryophyta, Pteridophyta*, etc.

S. No. 92. (cf. S. No. 79). Among spores being the result of a sexual fusion we may distinguish:
1a. the product of the sexual fusion (zygote, see S. No. 119) develops at once into a spore.
2a. zygospores. They are the product of conjugation. See S. No. 121. *Spirogyra, Mucor mucedo, Navicula viridula.*

2b. oospores. They are the product of oogamy and are always resting spores. See S. No. 121 and S. No. 87. *Chara, Oedogonium, Vaucheria.*

1b. the product of the sexual fusion (zygote, see S. No. 119) develops into spores after having undergone a certain number of cell reproductions. Here we may distinguish the following terms:

2a. carpospores. They are the product of a carpogonium. See S. No. 128. *Florideae.*

2b. basidiospores. They are the product of conjugation. *Panaeolus campanulatus* [1]).

2c. ascospores. They are the product of an ascogonium. See S. No. 100 and S. No. 128. *Ascomycetes.*

S. No. 93. (cf. S. No. 79). Spores whose formation is preceded by a reduction division may sometimes exhibit more or less distinctly a male or female character and in this respect we may distinguish the following cases:

1a. Neutral spores. They all have the same shape and show no visible sexual characters. They may produce:

2a. monoecious offspring. (cf. S. No. 21). *Oedogonium.* androgynous species; isosporous *Pteridophyta* and *Lycopodinae.*

2b. dioecious offspring. (cf. S. No. 21). *Equisetum.*

1b. the spores themselves exhibit already a male or female character and then we distinguish:

2a. microspores of the lower and pollen-grains of the higher plants. They are relatively small male spores and give rise to more or less developed prothallia, which produce male gametes.

2b. mega- or macrospores of the lower and embryo-sacs of the higher plants. They are relatively large female spores and give rise to more or less developed prothallia, which produce female gametes.

With respect to the occurrence of micro- and megaspores we may distinguish heterosporous forms, whilst those forms having only spores of one shape are called isosporous.

S. No. 94. (cf. S. No. 79). Polarity of base and apex in spores. In haploid spores a polarity of base and apex is of rather frequent occurrence and in this respect the spores in question may be divided into the following groups:

1a. neutral spores, microspores and megaspores. Base and apex depend upon the position of the spore with respect to its spore mother-cell, which divides into a tetrad, so that the basis corresponds to the outward face of the spore mother-cell, whilst the apex corresponds to its central part. According to the place of dehiscence exhibited by the germinating spore, we may distinguish:

2a. acroblastic spores. The dehiscence takes place at the apex of the spore. The large majority of all kinds of spores in *Bryophyta* and *Pteridophyta.*

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[1]) R. van den Dries. Recherches sur le déterminisme sexuel des Basidiomycètes, 1920. Mémoires Académie Royale de Belgique.

2b. basiblastic spores. The dehiscence takes place at the base of the spore. This is a rare case, exhibited for instance by the spores of *Sphaerocarpus terrestris,* which when ripe, nevertheless remain united together in a tetrad, so that acroblastic germination is out of the question. Perhaps it may occur also here and there in *Pteridophyta.*

1b. pollen-grains. Base and apex depend here also on the position of the pollen-grain with respect to its pollen mother-cell, so that again the base corresponds to the outward face of the pollen mother-cell, whilst the apex corresponds to its central part. According to the place of exit of the pollen-tube from the germinating pollen-grain [1]), we may distinguish:

2a. acrosyphonic pollen-grains. The pollen-tube is formed at the apex of the pollen-grain. Examples did not come to my knowledge.

2b. basisyphonic pollen-grains. The pollen-tube is formed at the base of the pollen-grain. All *Coniferae;* most *Monocotyledons,* for instance *Gramineae;* among *Dicotyledons* rare, for instance *Drymis.*

2b. pleurosiphonic pollen-grains. The pollen-tube is formed in any place between base and apex. Most Dicotyledons, for instance Lythrum Salicaria.

1c. embryo-sác. Base and apex here by no means coincide with a certain position in a mother-cell of the embryo-sac. Here however base corresponds to the base of the nucellus in the ovule and means the part turned towards the chalaza, whilst the apex is turned upwards towards the micropyle. According to the place of the egg-apparatus and antipodes we may distinguish:

2a. acrogamic embryo-sacs. [2]) The egg-apparatus is turned towards the summit of the embryo-sac, the antipodes are basal. The great majority of *Angiospermae.*

2b. basigamic embryo-sac. The egg-apparatus is turned towards the base of the embryo-sac, and the antipodes towards the summit. This is a phenomenon of rare occurrence and is exhibited by the majority of *Balanophoraceae*, where it is complicated with chalazogamy and by *Loranthaceae* with a peculiar development of the ovary.

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[1]) Goebel, Organographie der Pflanzen 2. Aufl., Teil III, Jena 1922. p. 1539, uses the term polysyphonic (German polysiphone) to indicate pollen-grains with more than one place of exit, like those of *Campanula* and *Cucurbita.* In some cases of this kind, for instance *Malva,* a single pollen-grain may under certain circumstances produce more than one pollen-tube and then use of the term polysyphonic might seem to be appropriate, yet wholly superfluous. For the production of several pollen-tubes by one pollen-grain is a phenomenon of slight importance, because each pollen-grain possesses the generative cells only sufficient for a single normal fertilisation, so that only one tube can have effect; thus it seems superfluous to have a term for this phenomenon.

[2]) Van Tieghem, Acrogamie et Basigamie, Journal de Bot., IX, 1895, p. 465. The terms acro- and basigamic were used by Goebel, Organographie 2nd ed. 1922, p. 1539, for indicating the place where the male nucleus or nuclei leave the pollen-grain, but they do not seem applicable in this case, because there is no question of fertilisation but only of the production of a pollen-tube by a pollen-grain, whilst the terms of Van Tieghem moreover claim priority.

S. No. 95. (cf. S. No. 79). Pycnospores or pycnoconidia. They are a special kind of spores of uncertain nature, produced by abstriction from conidiophores in fructifications which are called pycnidia (see S. No. 170); they are very small, exhibiting a lower order of magnitude than any other kind of spores. *Cryptospora hypodermia, Strickeria obducens* and other *Pyrenomycetes.*

In several characters they show a close relationship with the spermatia of *Lichenes* (see S. No. 123) and the same may be said of pycnidia and spermogonia (see S. No. 170).

S. No. 96. (cf. S. No. 78). Conidiophores or sporophores. They are more or less cylindrical, simple or ramified uni- or pluricellular organs, producing conidia by abstriction. The production of conidia often takes place at the top of sterigmata, thin stalk-like parts each bearing either a single conidium *(Psalliota campestris)* or shorter or longer chains of them *(Aspergillus glaucus, Penicillium italicum)*.

Basidium is a term used for a special kind of conidiophores. See S. No. 130.

S. No. 97. (cf. S. No. 78). Concerning the term sporangia the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 98.
1b. unicellular and pluricellular sporangia (see S. No. 99), the latter including synangia (see S. No. 105).
1c. unicellular sporangia: sporangium proper and sporangiophore. See S. No. 100.
1d. pluricellular sporangia: ordinary pluricellular and sporogonia. See S. No. 99.

S. No. 98. (cf. S. No. 97). Sporangia. This term designates all organs which without the intervention of fructifications produce endospores directly.

S. No. 99. (cf. S. No. 97). With respect to the grade of differentiation we may distinguish:
1a. unicellular sporangia. Their spores are all contained within a single cell. Many *Algae* and *Fungi*. See S. No. 100.
1b. pluricellular sporangia. Their spores are contained in an internal cavity within a pluri- and often multicellular body. Here we may distinguish:
2a. ordinary pluricellular sporangia. They exhibit a relatively simple differentiation and from their developmental characters belong to the appendages of the outer surface and the

surfaces of internal cavities. *Myxomycetae; Pteridophyta; Gymno-* and *Angiospermae,* nucellus of ovule and pollen-sacs. See S. No. 101.

2b. sporogonia. They have a more complex differentiation and exhibit several particular characters; they represent a complete sporophyte and develop from a fertilised egg-cell in an archegonium. *Bryophyta.* See S. No. 108.

S. No. 100. (cf. S. No. 97). Unicellular sporangia. Here we may distinguish:

1a. the sporangium proper. It is a cell possessing a cell wall and containing the spores. It may appear in different grades of development. In the simplest case the protoplast is transformed into a single swarm-spore *(Vaucheria* and *Oedogonium,* asexual swarm-spores), but in other cases this transformation is preceded by divisions of the protoplast which may be very numerous *(Saprolegnia,* asexual swarm-spores). In other cases again there are formed non-motile spores, from one up to many in number; they may be naked spores (tetraspores) or walled spores and in the latter case there may appear a central columella which arises by the bulging out into the sporangium of the transverse wall separating the sporangium from its sporangiophore *(Mucor, Pilobolus).*

For a peculiar kind of unicellular sporangia the term ascus is used. See S. No. 130.

1b. the sporangiophore. This is the part bearing the sporangium proper, either one or more. It may be wanting when the sporangia are simply cells belonging to the vegetative body, like *Vaucheria* and *Oedogonium,* producing asexual swarm-spores or like many tetrasporangia (cf. S. No. 89). When present it may be slightly developed, but in other cases relatively large *(Mucor Mucedo)* or even branched *(Phytophtora infestans).*

S. No. 101. (cf. S. No. 99). Concerning ordinary pluricellular sporangia the following subjects will be dealt with:

1a. sporangia proper (wall and contents) and stalk. See S. No. 102.
1b. dimorphic sporangia. See S. No. 106.
1c. micro- and macro- or megasporangia. See S. No. 107.

S. No. 102. (cf. S. No. 101). Ordinary pluricellular sporangia. Here we may distinguish:

1a. the sporangium proper. This is the capsule containing the spores and in it the following parts may be distinguished:

2a. the sporangium wall. At first a few cell layers thick, of which in a mature state only the outer one *(Filices)* or a smaller or larger number *(Angiospermae,* pollen-sacs or nucellus of ovule) may remain. See S. No. 103.

2b. the contents of the sporangium. In a mature state consisting of the spores sometimes mixed with sterile cellular elements or some parts which are developed from the tapetum. See S. No. 104.

1b. the stalk. This is the part bearing the sporangium proper; it may be more or less developed *(Filices)*, uni- or pluricellular and also wanting, so that the sporangium is sessile *(Isoetes)*.

S. No. 103. (cf. S. No. 102). The sporangium wall. Here we may distinguish the following special differentiations:
1a. fibrous layers. One or more layers of cells with annular, spiral or reticulate thickenings of their walls. *Equisetum*, the outer cell layer; *Angiospermae*, the fibrous layer of the pollen-sacs (see S. No. 721).
1b. a ring or annulus. This is one row of cells [1]) with strongly thickened radial and inner walls, and appears in different forms.
2a. a complete annulus.
3a. an apical annulus. It surrounds the apex of the capsule. *Schizaeaceae*.
3b. it passes obliquely over the apex of the capsule. *Cyatheaceae*.
2b. an incomplete annulus. It extends from the stalk over the dorsal side and top to the middle of the ventral side of the capsule. *Polypodiaceae*.
2c. a reduced annulus. The annulus is represented merely by a group of thick-walled cells just below the apex of the sporangium. *Osmundaceae*.
1c. the tapetum. This is the innermost part of the sporangium wall, consisting of one or a few layers of cells, often rich in protoplasmic contents. It may be persistent *(Lycopodineae)*, but in a mature state may have disappeared, often having wandered in between the developing spores, so that these lie embedded in a mucilaginous protoplasmic mass, called periplasm *(Filices, Angiospermae*, pollen-sacs). See moreover S. No. 128.

S. No. 104. (cf. S. No. 102). The sporangium contents. Here we may distinguish:
1a. spores, pollen-grains or embryo-sacs. Their number is various, amounting from one *(Salvinia*, macrosporangia; *Angiospermae*, embryo-sac) up to a great number *(Filices*, sporangia). They arise from one or more cells called archesporium forming mostly a sporogenous tissue, the cells of which ultimately develop into spore-mother-cells, dividing into spores. There is often a tendency of spores to cluster together more or less and in this respect we may distinguish:
2a. spore-tetrads. (See S. No. 484). Four spores arising from the same mother-cell more or less remain together. *Salvinia*, microspores; *Rhododendron*, pollen.
2b. pollinia [2]). All pollen-grains of a theca are clustered to-

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[1]) In fossil *Botryopteridaceae* the annulus exhibits more than one row of cells.

[2]) Pollinia have been sometimes called massulae, but it is better to use the latter term in another sense, as has been done in the text. See moreover S. No. 339.

gether by means of an interstitial substance which is prolonged into a tail or caudicle. *Asclepiadaceae, Orchideae,* pollen.

See moreover 1b, 2c, 3a.

1b. sterile parts. They are represented by:

2a. trabeculae. They are transverse plates of parenchymatous tissue imperfectly dividing the sporangium into a series of chambers. *Isoetes,* micro- and megasporangia.

2b. tapetal or perinial elaters. See 1b, 2c, 3c.

2c. parts formed from the tapetum. With respect to these parts the following terms are in use:

3a. massulae. They are clusters of spores united together by a hardened frothy interstitial substance derived from the tapetal cells. *Salvinia,* microspores united into a single massula [1]; *Azolla,* microspores united into two up to eight massulae in one microsporangium. In *Azolla caroliana* and *filiculoides* the several massulae have on their surface hair-like appendages barbed at their upper end, which are called *glochidia.*

3b. perinium. This is an envelope investing a single spore corresponding in its character and origin to the interstitial substance of the massulae. *Salvinia* and *Azolla,* megaspores: *Equisetum,* spores.

3c. perinial or tapetal elaters. These are two spiral bands formed by the perinium which are attached to the ripe spore only at their point of intersection; they are hygroscopic, becoming uncoiled on drying and closing around the spore when moistened. *Equisetum,* spores. See 1b, 2c, 3b.

S. No. 105. (cf. S. No. 97). Synangium. This term designates a kind of compound sporangia arising by a coalescence of several, often many sporangia, so that a series of loculi ensues. *Marattiaceae, Bennettites.*

S. No. 106. (cf. S. No. 101). With respect to differences in development on the same plant individual, there may occur dimorphic sporangia and in this case we may distinguish:

1a. large sporangia, containing many spores.

1b. sporangioles. They are small and contain only a few spores.

Thamnidium, asexual reproduction.

S. No. 107. (cf. S. No. 101). With respect to reproduction of male or female spores we may distinguish:

1a. microsporangia, producing microspores.

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[1] The term massulae is often used only in those cases, such as *Azolla,* where the microsporangia contain more than one cluster of spores, but I can see no objection against the use of this term in the case of *Salvinia.* See also the preceding footnote, pollinia.

1b. macro- or megasporangia, producing macro- or megaspores.
Confer moreover S. No. 93.

S. No. 108. Sporogonium (cf. S. No. 97 and No. 99, 1b, 2b.) Concerning the term sporogonium the following subjects will be dealt with:
1a. the seta or stalk. See S. No. 109.
1b. the theca or capsule containing the spores. See S. No. 110.
1c. the calyptra or hood, formed by the wall of the archegonium in which the sporogonium is developed. See S. No. 115.
1d. dispersal of spores. See S. No. 116.

S. No. 109. (cf. S. No. 108). The seta or stalk. In most cases it is well developed and may be even very long *(Pellia epiphylla, Polytrichum)*, but in other cases it may consist only of a foot *(Anthocerotaceae)* or it may be wanting *(Ricciaceae)*. It is more or less cylindrical and in it the following parts may be distinguished:
1a. the foot. This is the basal part and is hidden in the body of the gametophyte bearing the archegonium from which the sporogonium arises. It may taper downwards *(Polytrichum)*, in other cases it is expanded more or less spherically *(Sphagnum)* or it may be smaller and provided at its surface with rhizoid-like papillae *(Anthocerotaceae)*.
1b. the apophysis. This is the upper part where it joins the theca. It may extend into a swollen annular protuberance *(Polytrichum commune)* or even into a relatively large collar-like disc *(Splachnum)*.

S. No. 110. (cf. S. No. 108). Concerning the term theca the following subjects will be dealt with:
1a. the wall. See S. No. 111.
1b. a columella. See S. No. 112.
1c. a spore-sac. See S. No. 113.
1d. spores and other contents. See S. No. 114.

S. No. 111. (cf. S. No. 110). The wall of the sporogonium. This may consist of only a single cell layer *(Riccia fluitans, Marchantia polymorpha)* or of a few cell layers *(Jungermannia)* and in both cases it is composed of parenchyma cells often exhibiting band-like or spiral wall thickenings (fibrous layer). In other cases it is sometimes provided with stomata *(Anthoceros, Musci)* and a well differentiated ground-tissue.

S. No. 112. (cf. S. No. 110). The columella of the sporogonium. This is an axial mass of tissue extending from the base through the cavity of the theca longitudinally upwards. It may be wanting *(Marchantia polymorpha, Jungermannia)*; in other cases it is hair-like and composed of a few rows of cells *(Anthoceros)*; in other cases again it may be more massive *(Polytrichum, Funaria)*, even dome-shaped *(Sphagnum)*; it may be confined to the more basal part of the theca *(Anthoceros, Sphagnum)* or reach to the top of the theca *(Funaria hygrometrica)* and in the latter case it may end at its top in a horizontal membrane closing the cavity *(Polytrichum)*, moreover it is sometimes surrounded by tissue resembling the ground-tissue of the wall *(Polytrichum)*.

S. No. 113. (cf. S. No. 110). The spore-sac. This is a layer of cells surrounding the spores. It may be wanting *(Marchantia polymorpha, Jungermannia)*; it may be a flat hemispherical sac arching over the columella *(Sphagnum)*; it may also have a more or less cylindrical shape — though sometimes exhibiting longitudinal folds — and laterally surround the columella. In the latter case it may surround the mass of the spores on the outside while it is bounded on the inside by the columella *(Mnium hornum)* or the spores are bounded outwards by an external spore-sac and separated inwards from the columella by an internal spore-sac *(Polytrichum)*.

S. No. 114. (cf. S. No. 110). Contents of the sporogonium. Here we may distinguish:
1a. the spores.
1b. cellular elaters. They are mixed with the spores. They may be wanting *(Riccia, Musci)*; in other cases they are fibres provided with spiral thickenings of the walls *(Marchantia polymorpha)*; in other cases again they are pluricellular and often forked *(Anthoceros)*. See also S. No. 158.

S. No. 115. (cf. S. No. 108). Calyptra. The archegonium wall at first develops together with the sporogonium till a stronger growth in length of the seta takes place. Then two cases may occur:
1a. the calyptra is broken through at the top and persists at the base of the sporogonium in the shape of a sheath. *Marchantia polymorpha, Sphagnum.*
1b. the calyptra is ruptured at its base and carried up as a cap covering the theca. *Andreaea, Phascum, Polytrichum.*

S. No. 116. (cf. S. No. 108). Sporogonium, dispersal of spores. At maturity the theca opens and sets free the spores. This dehiscence of the theca may take place in the following ways:
1a. by disorganisation and decay of the sporogonium wall when the spores are ripe. *Riccia, Archidium, Pleuridium.*
1b. with valves. The wall is divided into longitudinal parts which remain united only at their base. *Anthoceros* (two valves), *Jungermannia* (four valves).
1c. with teeth. The valves remain united for the greater part of their length and separate from one another only at their top. *Marchantia polymorpha.*

1d. with clefts. The valves remain united only at their base and top. *Andreaea.*
1e. with an operculum or lid. This is formed by the upper part of the theca. In this case we may distinguish:

2a. an annulus or ring. This is a narrow zone of specially differentiated epidermal cells at the margin of the operculum where the dehiscence takes place.

2b. a peristome. This is a fringe of from two to sixty-four tooth-like appendages at the mouth of the theca becoming visible when the operculum is thrown off and sometimes coalescing at their base into a continuous membrane. It may be wanting *(Sphagnum)*. In many cases there is a double peristome *(Mnium hornum)* and then the appendages constituting the outer peristome are called teeth and those of the inner peristome are called cilia.

S. No. 117. (cf. S. No. 78). Primary reproduction organs of various kinds leading to asexual or vegetative reproduction Here we may distinguish the following cases:
1a. there is no differentiation of certain parts having more especially the function of asexual reproduction.

2a. in unicellular plants. There are cell divisions, followed by separation of the daughter cells. Many *Bacteria, Diatomeae.*
2b. in pluricellular plants.
3a. portions of the mother plant, not specially differentiated, are separated from it by more or less accidental means. Dispersal of *Elodea canadensis* by accidental isolation of certain parts; formation of protonema from all parts of the seta of a moss-sporogonium which is cut into pieces; cuttings and grafts in horticulture; *Azolla,* lateral shoots set free by death and disruption of the parent axis as a regular means of reproduction.
3b. hormogonia. This term designates not specially differentiated parts of the filamentous thallomes which, as a regular means of reproduction, are separated and set free. *Nostocaceae.*
1b. there is a differentiation of special parts having the function of reproduction. These special parts have often the form of buds, but may also be represented by chlamydospores or tubers of different kinds.
2a. in unicellular plants. There is cell budding followed by separation of the buds from the mother cell. *Saccharomyces cerevisiae.*
2b. in pluricellular plants.
3a. spores and conidia of several kinds. *Puccinia graminis,* uredospores; *Mucor Mucedo* and *Penicillium crustaceum,* asexual spores; *Ustilagineae,* chlamydospores.
3b. buds of a thalloid character.
4a. soredia. They are small groups of dividing gonidia closely entwined with fungal hyphae forming isolated bodies, which by rupture of the thallus are scattered and give rise to new plants;

they often are formed in well-defined groups called sorales. Heteromerous *Lichens,* e.g. *Parmelia physodes, Roccella tinctoria.*

4b. starch-stars. Tuber-like subterranean bodies with much-shortened so called leaf-whorls. *Chara stelligera.*

3c. buds of a cormoid character.

4a. buds arising from a protonema. *Mnium hornum.*

4b. buds arising from runners or stolons (see S. No. 297) and growing out into new plants. *Fragaria vesca* and *Potentilla Anserina,* surface runners; *Valeriana officinalis,* subterranean runners.

4c. buds arising from leaves. *Aspidium Filix mas* and *Pteris aquilina,* at the bases of the petioles; *Asplenium decussatum, Ceratopteris thalictroides* and *Asplenium furcatum,* from the lamina; *Bryophyllum calycinum, Cardamine pratensis* and *Begonia rex,* from the lamina.

4d. buds arising from roots. They are of endogenous origin. *Linaria vulgaris, Populus tremula* and *Pyrus Malus.*

4e. bulbils. Small bulbs. *Lilium bulbiferum, Dentaria bulbifera,* in the axils of the leaves; *Cystopteris bulbifera,* on the leaf-blades; *Allium vineale* and *Poa bulbifera,* in the place of flowers.

3d. root-tubers with a slightly developed bud, sometimes called tuber-gemmae. *Ranunculus Ficaria* in the axils of the leaves and as root-tubers.

3e. buds growing from appendages of the surface.

4a. certain brood-buds, mostly called gemmae. *Marchantia polymorpha; Tetraphis pellucida.*

4b. small tubers. *Chara aspera,* and *Barbula,* products of rhizoids.

3f. adventitious embryos in cases of polyembryony, parthenogenesis, apogamy and apospory.

S. No. 118. (cf. S. No. 78). Concerning the term gamete the following subjects will be dealt with:

1a. the meaning of the term. See S. No. 119.
1b. plano- and aplanogametes. See S. No. 120.
1c. isogamy and oogamy. See S. No. 121.
1d. isogamy: scalariform and lateral conjugation. See S. No. 122.
1e. oogamy: female and male gametes. See S. No. 123.
1f. coenogametes. See S. No. 124.

Two additional articles will follow:

1g. fertilization: several combinations of gametes. See S. No. 129.
1h. development of the zygote without or with the intervention of spores of various kinds. See S. No. 130.

S. No. 119. (cf. S. No. 118). Gametes. This term designates reproductive cells which are capable of fusing together with other cells of the same or of a similar kind; they are mostly naked cells and generally are provided with a single nucleus. Thus two gametes produce again a single cell which is called a zygote and grows out into a new plant. The term fertilization is used in a general sense for the fusion of two gametes. The predominant feature of this phenomenon is the fusion of the two cell nuclei of the gametes; this fusion is known as karyogamy. In some cases delayed karyogamy occurs, i.e. the two nuclei do not fuse, but only lie next to each other; karyokinesis takes place in this condition in the peculiar form of conjugated karyokinesis (see S. No. 485). Karyogamy may then take place after a considerable number of nuclear divisions. Examples of this kind may be found in basidia and asci. Confer S. No. 96 and S. No. 100.

S. No. 120. (cf. S. No. 118). With respect to their faculty of moving we may distinguish:
1a. planogametes. They are motile, by means of cilia. (cf. S. No. 15).
1b. aplanogametes. They are not motile, and in some cases may be invested with a cell wall. See S. No. 123.

S. No. 121. (cf. S. No. 118). In fertilization we may distinguish.
1a. isogamy, conjugation or isogamous fertilization (isogamous plants). The gametes which fuse together are the same in outward appearance. They may be swarm-spores which are set free *(Ulothrix zonata)*, or they are non-motile without special external differentiation and fuse together while remaining within cell walls *(Spirogyra, Mucor Mucedo)*. The zygote formed in this process is mostly a zygospore (cf. S. No. 92). See further S. No. 122.
1b. oogamy or oogamous fertilization (oogamous plants). The gametes which fuse together are different in outward appearance, so that a male and female gamete may be distinguished. See S. No. 123.

S. No. 122. (cf. S. No. 118). In conjugation we may distinguish two special forms:
1a. scalariform conjugation. It is preceded by the formation of a canal between the cell walls of adjacent filaments, through which the protoplast of one cell passes into the other. *Spirogyra crassa.*
1b. lateral conjugation. It is preceded by the development of lateral processes from two adjacent cells of the same filament in the vicinity of the partition-wall; by coalescence of those processes a canal is formed through which the protoplast of one cell passes into the other. *Spirogyra longata.*

S. No. 123. (cf. S. No. 118). In oogamy we may distinguish:
1a. female gametes, egg-cells or ova, which are designated by the term oospheres, when the protoplast, even if still enclosed in a cell wall, is more or less rounded off *(Oedogonium, Fucus)*. They are mostly considerably larger than the male gametes

of the same plant; they exhibit a relatively large amount of cytoplasm and often plastids, but no cilia; there may appear a more transparent and in coloured oospheres a colourless receptive spot where the union with the male gamete takes place *(Chara, Oedogonium)*.

1b. male gametes. They may appear in the following shapes:

2a. swarm-spores. Cf. S. No. 84. *Oedogonium,* swarm-spores produced by dwarf males.

2b. spermatozoids. They exhibit a relatively small amount of cytoplasm, no plastids, but always cilia, often two but in other cases a much larger number *(Cycadaceae)*; they and their nuclei are often spirally coiled, even corkscrew-like *(Ferns)*, but may be also club-shaped *(Selaginella stolonifera)*, spindle-shaped *(Phaeophyceae)* or even conical *(Cycas)*.

2c. spermatia. They are non-motile, without cilia and may be naked *(Laboulbeniaceae)* or even invested with a cell wall *(Batrachospermum moniliforme)* just before fertilisation. They may be produced:

3a. within gametangia (antheridia, see S. No. 128). *Batrachospermum, Nemalion, Polysiphonia.*

3b. free, by abstriction after cell division; on gametophores (cf. S. N. 96) which are contained in special fructifications called spermogonia (see S. No. 170). *Parmelia, Peltigera.*

2d. male protoplasts, without the special external differentiation and contained in male gametangia, from which they pass into adjacent female gametangia, without being set free, while they remain enclosed within cell walls. *Saprolegnia, Sphaerotheca castagnei, Pyronema confluens.*

S. No. 124. (cf. S. No. 118). Coenogametes. This term designates gametes which exhibit more than one nucleus. *Mucor; Pyronema confluens,* carpogonia and antheridia; *Saprolegnia.*

S. No. 125. (cf S. No. 78). Gametophores or spermatiophores. They are short or somewhat longer and sometimes branched cylindrical bodies, which produce spermatia by abstriction *(Peltigera, Parmelia)*.

S. No. 126. (cf. S. No. 78). Concerning the term gametangia the following subjects will be dealt with:

a. the meaning of the term. See S. No. 127.

1b. kinds of female and male gametangia. See S. No. 128.

S. No. 127. (cf. S. No. 126). Gametangia. This term designates in isogamy as well as in oogamy all organs which directly and internally produce gametes.

S. No. 128. (cf. S. No. 126). Among gametangia in oogamy we may distinguish the following special kinds:

1a. female gametangia. They contain egg-cells, and with respect to their structure we may distinguish:

2a. the oogonium. It is always unicellular, it is sometimes a cell belonging to a thallome in all other respects of the same kind as its neighbours, in other cases a sessile or short-stalked, spherical, ovoid or barrel-shaped body containing one or more egg-cells or oospheres. *Oedogonium, Vaucheria, Sphaerotheca castagnei* and *Chara* with a single egg-cell and in the latter plant surrounded by a fructification consisting of five spirally wound enveloping tubes (see S. No. 162); *Fucus platycarpus* with eight egg-cells; *Saprolegniaceae* up to fifty egg-cells.

In a few cases the oogonium contains besides the egg-cell a peripheral plurinuclear protoplasm, which is called periplasm [1]) and after fertilisation forms an episporium, which is the outer part of the wall of the fertilised egg, when developed into an oospore. *Peronosporeae.*

2b. the procarp or procarpium. It is a body exhibiting an external differentiation into two parts, which nevertheless is often unicellular. In other cases cell division may have taken place so that the two parts are represented by separate cells; in other cases again the two parts may each consist of a certain number of cells. The reader is moreover referred to M. N. No. 12. In the external differentiation we may distinguish:

3a. the part containing the egg-cell or egg-cells which are not rounded off into oospheres and here we may distinguish:

4a. the carpogone or carpogonium. It produces after fertilisation and repeated cell divisions spores called carpospores (cf. S. No. 92), clusters of which may become surrounded by a special fructification called cystocarp (cystocarpium) (see S. No. 160). *Batrachospermum* and *Nemalion,* unicellular procarp; *Polysiphonia,* pluricellular procarp with separate trichogyne.

4b. the ascogone or ascogonium. It produces after fertilisation and repeated cell divisions asci containing ascospores, which may become surrounded by a special fructification called perithecium and apothecium (see S. No. 163 and 164). Conf. further S. No. 92 and S. No. 100. *Laboulbeniaceae,* unicellular ascogonium; *Ascolichenes: Collema crispum,* pluricellular, spirally coiled ascogonium.

3b. the trichogyne. This is a filament capable of receiving male gametes, often spermatia, but not always so *(Pyronema confluens,* where fertilisation takes place after open communication has been formed between the apices of trichogyne and cylindrical antheridium).

2c. the archegonium. It is a flask-shaped hollow pluricellular body, in which we may distinguish the following parts:

3a. a stalk. This is always short and in most cases wanting, so that the archegonium is sessile. An open sac-like envelope, called pseudo-perianth, may grow out of the stalk.

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[1]) See also S. No. 103.

3b. the archegonium proper, exhibiting:

4a. a venter. This is the basal dilated portion, with a wall consisting of a single layer of cells, whilst the contents are formed by the daughter-cells of the so-called central cell:

5a. an oosphere at the bottom of the cavity and

5b. a ventral canal-cell, smaller and above the oosphere.

4b. a neck. This is the narrow upper portion; its wall consists of a single layer of cells; those at the apex are called lid cells and separate from one another at maturity, so that the archegonium is opened, although in some cases the upper part of the neck is wholly thrown off *(Psilotum, Tmesipteris)*; its contents are formed of one or more neck canal-cells.

At maturity the ventral and neck canal-cells are disorganised and form a mucilage, which fills the space above the egg-cell and protrudes from the opened top of the neck, so that the male gametes, passing through it, may reach the oosphere. Archegonia are formed in all the higher plants from the *Bryophyta* upwards; their venter may be embedded in the part producing them, so that the neck only projects above the surface *(Ferns)*. In the higher groups they show a tendency to become rudimentary *(Gymnospermae)* and they may even disappear almost all together *(Angiospermae)*.

1b. male gametangia, antheridia or spermatangia. Here we may distinguish:

2a. naked antheridia. They do not possess a wall consisting of a parenchymatous tissue.

3a. unilocular naked antheridia. They consist of a single cell, which produces one or more male gametes. *Oedogonium crispum* and *O. Landsboroughi* with two male swarm-spores: *Laminaria digitata* with one spermatozoid; *Polysiphonia subulata,* with numerous spermatia; *Fucus vesiculosus,* with numerous spermatozoids; *Saprolegnia mixta,* containing a male coenogamete (cf. S. No. 124), without special external differentiation.

3b. plurilocular naked antheridia. They consist of more than one, often a large number of cells, each containing a single or a few spermatozoids; they have the shape of shorter or longer filaments and the cells composing them are often disc-shaped. *Stilophora; Chara* and *Nitella,* with numerous cells and surrounded by a special fructification called globule (see S. No. 161); *Azolla filiculoides* and *Salvinia natans; Dictyota dichotoma.*

3c. dwarf males. This is a special kind of naked antheridia, developed from swarm-spores (called androspores, cf. S. No. 84); they consist of only a few sterile cells and at the apex a few cells producing male gametes in the shape of swarm-spores. *Oedogonium ciliatum, O. concatenatum* and *O. Braunii.*

2b. walled antheridia. They possess a wall consisting of parenchymatous tissue, surrounding the mother-cells of the gametes which here are always spermatozoids.

We may distinguish:

3a. a stalk. This may be wanting, short *(Marchantia polymorpha)*, but in some cases very long *(Sphagnum)*.

3b. the antheridium proper. This may be globular *(Sphagnum, Aspidium Filix mas)* or club-shaped *(Musci)*.

It is composed of:

4a. the wall. This consists of a single layer of parenchymatous cells and at maturity opens either at the top *(Mnium hornum)* or with two valves *(Sphagnum)*.

4b. the contents, consisting often of cubical and cubically arranged cells *(Marchantia polymorpha)*, which after repeated divisions produce spermatozoids.

Walled antheridia are to be found, like archegonia, in the higher plants from the *Bryophyta* upwards; in the higher groups they show a tendency to become rudimentary *(Gymnospermae)* and may even disappear almost all together *(Angiospermae)*.

S. No. 129. (cf. S. No. 118). In fertilisation gametes may combine in the following ways:

1a. in isogamy.

2a. two swarm-spores fuse together. *Ulothrix zonata.*

2b. two gametes, not showing a special external differentiation, fuse together. In these cases the gametes are formed in cells, which come into contact with one another, after which apertures in their cell walls are formed, through which the gametes may pass, so that a union may take place, while they remain surrounded on all sides with cell walls. *Spirogyra, Panaeolus campanulatus.*

1b. in oogamy:

2a. an egg-cell fuses with a swarm-spore. *Oedogonium.*

2b. egg-cells and spermatia fuse by mediation of a trichogyne. *Polysiphonia* with carpogonium; *Ascolichenes* with ascogonium.

2c. an egg-cell fuses with a male gamete without special external differentiation. *Saprolegnia, Pyronema confluens* (cf. S. No. 128, 1a, 2b, 3b).

2d. an egg-cell fuses with a spermatozoid. *Vaucheria; Fucus; Chara; Bryophyta; Pteridophyta; Cycadaceae; Ginkgo biloba.* In the higher *Gymnospermae* and *Angiospermae* the male gametes have become more or less simplified.

S. No. 130. (cf. S. No. 118). Development of zygotes. In most cases, soon after fertilisation has taken place they are invested with a cell-membrane. They then may grow out at once into a new plant, generally passing through an embryonic stage, and the developmental cycle down to the next sexual reproduction may be completed without the intervention of spores *(Fucus serratus)*. In the great majority of cases however the developmental cycle is not completed before spores have been formed and here we may distinguish the following cases:

1a. the zygote itself is transformed into a spore. There is no antithetic alternation of generations.

2a. zygospores. They are the product of conjugation. *Spirogyra, Mucor mucedo, Ulothrix zonata.*

2b. oospores. They are the product of oogamy. *Vaucheria, Chara.*

1b. the zygote exhibits a smaller or larger number of cell divisions before the spores are formed. There is antithetic alternation of generations.

2a. the number of cell divisions (by which a sporophyte is formed) is more or less restricted, whilst from the spores there develops a body (called gametophyte) which often possesses considerable dimensions and again produces sexual organs.

3a. carpospores. They are developed from carpogonia which produce sporogenous filaments or gonimoblasts, sometimes called conjugating tubes; in many cases the production of carpospores from the sporogenous filaments is accompanied by a fusion of these filaments with so-called auxiliary cells; they may be haploid or diploid and the alternation of generations is haplo- or diplobiontic. Conf. for the rest S. No. 128, 1a, 2b, 3a, 4a. *Batrachospermum moniliforme,* without auxiliary cells, with haploid carpospores and a cystocarp; *Dudresnaya coccinia* with auxiliary cells; *Scinaia* with haploid carpospores; *Polysiphonia* and *Delesseria* with diploid carpospores.

3b. ascospores. They are developed from ascogonia which produce ascogenous filaments, after having been fertilised; fusion of the parent nuclei does not take place at once and thus the cells of the ascogenous filaments each contain two nuclei exhibiting a conjugated karyokinesis (see S. No. 485), till in the young ascus karyogamy (cf. S. No. 119) takes place and is soon followed by a reduction division (see S. No. 482); in the ascus there are produced from one to many walled haploid spores, the number eight being of most general occurrence; these spores sometimes may be pluricellular (cf. S. No. 80); the alternation of generations is diplobiontic. Conf. further S. No. 128, 1a, 2b, 3a, 4b. *Tuber cibarium* (four ascospores). *Peziza* (eight ascospores), *Thecotheus* (thirty two ascospores).

3c. basidiospores. They are the consequence of conjugation, mostly followed by the production of fructifications, which may exhibit a high grade of development; fusion of the parent nuclei does not take place at once and thus the cells of the fructifications each contain two nuclei exhibiting a conjugated karyokinesis (see S. No. 485) often accompanied by a formation of so-called clamp-connections; ultimately conidiophores termed basidia (cf. S. No. 96) are formed which are mostly unicellular, though they may be divided by transverse *(Uredineae, Auricularieae)* or longitudinal *(Tremellineae)* walls and in this case generally four cells are formed; the basidia by means of cell budding produce basidiospores often at the top of sterigmata, though these may be wanting; in the young basidium karyogamy (cf. S. No. 119) takes place and is soon followed by a reduction division; the number of spores produced by each basidium is generally four though other numbers and sometimes large ones may occur *(Ustilagineae)*; they are walled and haploid spores; the alternation of generations is diplobiontic. *Hymenomycetes.*

3d. the spores produced by sporogonia (see S. No. 99) which are not designated by a special term. They are haploid and the alternation of generations is diplobiontic. *Bryophyta.*

2b. the number of cell divisions is unlimited in so far as the formation of spores takes place at the end of a considerable development (sporophyte), whilst from the spores relatively insignificant or even quite rudimentary bodies develop (gametophyte) ending in the production of sexual organs.

3a. the swarm-spores produced by the sporophytes of Laminariaceae. *Laminaria digitata.*

3b. the spores produced by the sporophytes of isosporous Pteridophyta and developing into monoecious or dioecious prothallia. They are walled haploid spores and are not designated by a special term; the alternation of generations is diplobiontic. *Asplenium Filix mas; Equisetum* (dioecious); *Lycopodium.*

3c. megaspores and microspores (cf. S. No. 93). They produce more or less rudimentary female or male prothallia; they are haploid; the alternation of generations is diplobiontic. Heterosporous *Pteridophyta: Salvinia natans; Selaginella; Isoetes.*

3d. embryosacs and pollen-cells. They produce rudimentary female or male prothallia or only gametes. The embryosacs exhibit often larger and sometimes considerable dimensions *(Cocos nucifera)*. They are haploid and the alternation of generations is diplobiontic. *Gymnospermae* with rudimentary prothallia; *Angiospermae.*

S. No. 131. (cf. S. No. 76). Concerning sori and hymenia the following subjects will be dealt with:
1a. definition of the terms. See S. No. 132.
1b. sterile additional organs. See S. No. 133.
1c. distribution of sori and hymenia throughout the vegetable kingdom. See S. No. 134.

S. No. 132. (cf. S. No. 131). Groups of primary reproductive organs and of secondary reproductive organs directly producing spores or gametes, asexual or sexual, are of most common occurrence. These groups may consist only of the reproductive organs themselves; in cases of sexual reproduction they may consist only of male or female organs, but in other cases both sexes are intermixed; moreover sterile additional organs, to be dealt with in S. No. 133, are often mixed with these groups of reproductive organs in such a way, that they may be considered as belonging to them. For the rest these groups in many cases take part in the formation of extended fructifications, as in *Ascomycetes, Hymenomycetes* and *Filicinae.* For groups of these kinds the following terms are in use:

1a. synangium. A certain number of sporangia is combined by coalescence into a plurilocular organ. Conf. also S. No. 105: synangium. *Marattiaceae; Bennettites; Angiospermae:* thecae of anthers, each consisting of two loculi, see also S. No. 337.

1b. sorus. This term designates isolated, rather slightly extended groups, mostly covering in large numbers a certain area. *Puccinia Graminis,* sori of summer- and winterspores, without sterile additional organs; *Vaucheria sessilis,* sori of gametangia only, consisting of one oogonium and two antheridia; *Dictyota dichotoma,* sori of oogonia or antheridia [1]), the latter surrounded by a sterile additional indusium; *Chara,* eight sori of antheridia enclosed in a thalloid fructification, called globule; *Polypodium vulgare,* sori of sporangia, with a receptacle and paraphyses, making part of a fructification, called sporophyll; *Aspidium Filix mas,* like *Polypodium,* but moreover with an additional indusium; *Salvinia natans,* sori of micro- and megasporangia, mixed together, placed on an additional receptacle and enclosed in a globular indusium [2]); *Angio-* and *Gymnospermae,* ovules, containing only a single well developed megasporangium.

1c. hymenium. This term designates groups extending over the whole of a well defined area, often exhibiting relatively large dimensions. *Russula rubra,* basidial hymenium, with sterile additional paraphyses and cystids; *Peziza,* hymenium of asci, with sterile additional paraphyses; *Fucus platycarpus,* hymenium of oogonia and antheridia, with sterile additional paraphyses and periphyses; *Fusarium,* hymenium of conidia; *Puccinia Graminis,* aecidium stage [3]), hymenium of aecidiospores, surrounded with a sterile additional peridium; *Marchantia polymorpha,* gemma-cups, hymenium of gemmae, intermixed with sterile additional paraphyses.

S. No. 133. (cf. S. No. 131). Sterile additional organs, taking part in the formation of sori and hymenia.

1a. receptacle of sorus. This is a protruding, often cushion-like part of a sporophyll, on which the other parts of the sorus are borne; *Aspidium Filix mas; Salvinia natans.*

In hymenia no such appendages occur although a subhymenial layer of palisade cells may be present, which is sometimes considered as belonging to the hymenium. *Russula rubra.*

1b. indusium. This is a sterile additional and membranaceous part, springing from the receptacle and covering or enclosing sporangia; it is an appendage of the surface, belonging to the trichome type, (see S. No. 450 and S. No. 738), sometimes wanting all together *(Polypodium vulgare);* when occurring it may be peltate and more or less reniform *(Aspidium Filix mas),* or lip-shaped *(Scolopendrium).* .

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[1]) Strasburger, Lehrb. d. Bot., 16. Aufl., Jena 1923. p. 365.

[2]) The term sporocarps is often used for these sori, but it ought to be limited to organs, like those of *Marsilia.* See S. No. 234: sporocarps.

[3]) Goebel, Outlines of classification and special morphology of plants. Oxford 1887. p. 129.

2a. false indusium. This term designates a kind of indusium, not belonging to the appendages of the surface, but formed by the margin of the sporophyll, folded over and covering the sorus. *Pteris aquilina.*

1c. paraphyses. They are sterile additional organs, appendages of the surface, belonging to the trichome type and hair-like, but they are not restricted in their occurrence to sori and hymenia, because they also appear in cormoid receptacles, between the organs of reproduction. (see S. No. 450 and S. No. 738).

In sori and hymenia they often appear between sporangia or gametangia or surrounding them, so that they take part in the formation of those groups and we may distinguish among them:

2a. ordinary paraphyses. They are placed between the organs of reproduction and are very common. *Polypodium vulgare,* sori, between sporangia; *Peziza,* hymenium, between the asci; *Fucus,* hymenium, between the gametangia; *Marchantia Polymorpha,* hymenium of gemma-cups, between the gemmae.

2b. cystids. They are unicellular, larger protruding, globular or club-shaped tubes, with thickened walls occurring in addition to ordinary paraphyses. *Russula rubra,* hymenium.

2c. periphyses. They are paraphyses not placed between the reproductive organs, but surrounding their groups. *Podospora fimiseda,* hymenium of perithecium.

1d. peridium. In S. No. 153 the peridium is described as an enveloping outer layer of certain thalloid fructifications. In the majority of cases it must be considered as an autonomous organ and by no means as constituting only an additional part in the formation of sori or hymenia. Examples of autonomous peridia are afforded by *Lycoperdon,* and by *Chara* where each globule contains eight sori of antheridia. But in a few cases, if connected with hymenia it may be so insignificant, that it is generally considered as belonging to the hymenium, as in *Puccinia Graminis,* aecidium stage, and then it may be considered as a sterile additional organ.

S. No. 134. (cf. S. No. 131). Distribution of sori and hymenia throughout the vegetable kingdom. Discussing this subject it ought to be kept in mind that synangia are in fact only sori of which the sporangia have grown together, and that the thecae of the anthers in the higher plants in reality are synangia. It further must be kept in mind that the nucellus of an ovule is considered by all botanists on very good grounds as a megasporangium, although on the value of the integuments with respect to organotactical characters, different theoretical conceptions may exist.

Taking the above considerations into account, we may give the following survey of the distribution of sori. In *Thallophyta* they are by no means rare: *Puccinia Graminis,* summer- and winterspores; *Chara* (globule); *Dictyota dichotoma; Vaucheria sessilis.* In *Bryophyta* they do not appear, but are represented by cormoid receptacles. See S. No. 208. In *Pteridophyta* they do appear in *Filicinae,* where they are so common that it is needless to give examples, but in *Equisetinae* and *Lycopodinae* no sori exist and the sporangia are arranged in strobili. In *Gymnospermae* and *Angiospermae* they are of very general occurrence, in male and especially in female organs, but only in a very reduced state (nucellus of ovule, thecae of anthers).

The distribution of hymenia is much more limited, for they are wanting in all the higher plants, including *Musci.* They are only to be found in *Thallophyta* and here they may often extend over large surfaces; for instance in *Ascomycetes* and *Hymenomycetes,* taking part in the formation of large fructifications. It is not necessary to give here detailed examples.

S. No. 135. (cf. S. No. 68). Concerning phenomena disturbing and complicating the division into organs, the following subjects will be dealt with:

1a. displacement. See S. No. 136.
1b. concrescence, adnation, concretion, coalescence, symphysis, connation. See S. No. 137.
1c. doubling, duplication, collateral chorisis, dédoublement. See S. No. 138.
1d. abortion, atrophy. See S. No. 139.

S. No. 136. (cf. S. No. 135). Displacement. The original arrangement of organs with respect to the parts which produce them and to one another is altered by subsequent growth. The original relations are seldom exhibited in the early phases of development and their knowledge is mostly the result of studies in comparative morphology. The following examples may be cited: 1. many sympodia, displacement of the apex of a shoot by strong growth of a branch *(Vitis vinifera,* formation of tendrils; *Symphytum officinale,* inflorescence); 2. *Datura stramonium* and many other *Solanaceae,* displacement of subtending foliage leaves by growth of their adhering axillary branches; 3. perigynous and epigynous flowers, displacement of floral phyllomes by growth of their receptacle; 4. anatropous and campylotropous ovules, displacement of the funicle by growth of parts of the ovules; 5. ovary of *Punica Granatum,* displacement of external carpels by growth of the receptacle.

S. No. 137. (cf. S. No. 135). Concrescence, adnation[1]) concretion, coalescence, symphysis, connation. These terms are used for indicating the coalescence of parts which otherwise remain isolated. This coalescence is in most cases congenital; the original state is often not exhibited in early phases of development and its knowledge is often only due to comparative morphology. Gamosepalous calices and gamopetalous corollae; *Leguminosae,* stamens.

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[1]) Asa Gray. The Botanical Text-book, part I, Structural Botany, 6th ed. New York 1879, p. 181.

Coalescence of originally quite isolated organs rarely occurs. Asclepias, the cohesion of two stigmas to each other and to the anthers; *Benthamia fragifera,* fruits [1]).

S. No. 138. (cf. S. No. 135). Doubling, duplication, collateral chorisis (Eichler), dédoublement (Payer). This is a special form of branching at a very early period, causing the substitution of two or more stamens for one. *Cruciferae,* median stamens; *Fumariaceae; Malva.*

S. No. 139. (cf. S. No. 135). Abortion, atrophy. These terms are used in general for imperfect formation or non-formation of organs, but especially for those cases, in which the phenomenon occurs habitually and is the effect of internal causes, arising from the organisation of the plant itself. Organs habitually reduced to a certain extent were called by Darwin rudimentary organs [2]). *Vicia Faba,* top leaflets of foliage leaves; *Lathyrus aphaca,* leaflets; *Acacia diversifolia,* lamina of phyllodia; many unisexual flowers, stamens or pistils.

CHAPTER II.

ORGANOGRAPHICAL SYSTEM.

§ 1. Thallome. Confer for the meaning of this term S. N^0. 73.

A. General description.

S. No. 140. Among thallomes we may distinguish:

1a. unicellular thallomes, for which no special terms are in use; they are in general of slight dimensions and exhibit the most various shapes; they are often free and even motile, but in many other cases attached to substrata in various ways. *Chlorella* (free, also living symbiotically); *Navicula* (motile); *Botrydium granulatum* and *Gomphonema constrictum* (sessile). See moreover S. No. 143.

1b. the filamentous or filiform thallome. It is a slender thread and may be:

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[1]) Sachs. Lehrb. d. Bot. 4. Aufl. Leipzig 1874. p. 226.

[2]) Darwin. Origin of species 6th edition, London 1875, p. 398 and Animals and Plants under domestication II, 3rd edition, London 1888. Darwin used the term rudimentary in a peculiar sense, viz. in that of partial atrophy in the course of generations and considered those organs as procuring a powerful argument in favour of his theory. Many botanical writers later used the term rudimentary in its more general sense covering also those cases in which organs are in a nascent state leading to full development. I think that it is preferable to use the term in biology exclusively in the sense which Darwin has given to it, because for the phenomena cited by him a special term is indeed needed.

2a. unicellular. *Vaucheria.*

2b. multicellular and uniseriate. It may be unbranched *(Oscillaria; Spirogyra)* or branched *(Cladophora; Callithamnion; Pilayella littoralis; Ectocarpus arctus; Musci,* protonema), free floating or attached to a substratum by means of hapterae or rhizoids.

In some cases heterocysts occur in the filaments; they are single cells with modified contents. *Nostoc Linckii.*

1c. the thallus. This is a comprehensive term designating thallomes mostly multicellular and extending in at least two, often in the three directions of space. It is often coloured by pigments which are contained in plastids, but in many cases it may be coloured by other kinds of pigments or is even quite colourless.

With respect to shape we may distinguish:

2a. the foliaceous thallus. It is strongly expanded in two directions, flat and leaf-like, often lobed, deeply-cleft or perforated; it may be small, but in other cases exhibits considerable dimensions; it is attached to the soil or other substrata by means of rhizines, springing either from the whole under surface or only from its middle part, but it may also be attached at the base by means of hapterae (cf. S. No. 75), in a few cases it is free floating. *Aspidium Filix mas,* prothallium (rhizines); *Marchantia polymorpha* (rhizines); *Xanthoria parietina* (rhizines); *Ulva lactuca* (hapteres); *Delessaria sanguinea* (hapterae); *Laminaria saccharina,* with cylindrical basal part (hapterae); *Himanthalia lorea,* cup-shaped thallus proper with cylindrical basis; *Enteromorpha intestinalis* (free floating).

2b. the fruticose thallus. It is cylindrical or ribbon-shaped; it is often branched, sometimes extensively and in a shrub-like manner; it may be small *(Lessonia);* it is mostly attached at the base and may be erect or pendulous. *Ceramium; Polysiphonia; Chondrus crispus; Himanthalia lorea,* fructifications; *Clavaria botrytis,* fructifications; *Cetraria islandica; Cladonia rangiferina,* podetia; *Ephebe pubescens.*

2c. the crustaceous thallus. It is of slight dimensions, has the form of discs or scales and often exhibits the character of an incrustation; it mostly adheres closely to the soil or to a substratum of rock, bark of trees, etc. *Graphis scripta; Sphaerothallia esculenta; Melobesia Lejolisii; Coleochaete irregularis; Cladonia rangiferina,* primary thallus soon disappearing; *Anthoceros.*

2d. the tuberous thallus. It has the shape of a tuber (cf. S. No. 75). *Lycopodium clavatum,* prothallium; *Tuber cibarium* and *Lycoperdon,* fructifications.

1d. the mycelium. This term designates a thallome composed of hyphae, either septate or non-septate, branched or unbranched, which in the great majority of cases are devoid of coloured plastids. It seldom exhibits a characteristic individual shape, but is generally in this respect largely influenced by obstacles surrounding it. If it does not meet them in its growth, it has a strong tendency to extend equally on all sides, thus becoming circular or spherical *(Mucor,* spore germinating in a drop of water; Fairy-rings of toad-stools), but its shape is mostly dependent on its surroundings and irregular, especially if it is subterranean, like the vegetative body of mushrooms or belongs to parasites occupying internal cavities of their host-plants, like many *Fungi* growing in the intercellular spaces of other plants *(Puccinia graminis; Phytophthora infestans)* or the haustoria (cf. S. No. 75) of *Rafflesia* and *Pilostyles.* It sometimes resembles a cobweb *(Erysiphae),* but often exhibits a denser structure, in some cases even becoming leathery, especially when sclerotia are formed *(Rhizomorpha,* see S. No. 151). The protonema of *Musci* and filamentous thallomes growing in air as dense felt-like masses, like *Vaucheria terrestris,* may often exhibit several characters of a mycelium.

Promycelium is a term used for a short germ-tube arising from a spore and producing in its turn sporidia. (cf. S. No. 87). *Puccinia graminis,* germination of puccinia spores.

1e. the plasmodium. It is a mass of naked protoplasm originally formed by coalescence of protoplasts exhibiting amoeboid movements (myxamoebae); such small plasmodia may fuse together into larger ones and may grow out into bodies of considerable dimensions, creeping about on or in their substrata, changing their form and thrusting out processes (pseudopodia, see S. No. 514), which may in turn coalesce; they show a more compact external layer called plasmolemma and an internal streaming of protoplasm (see S. No. 514). The vegetative body of *Myxomycetes; Fuligo varians; Chondrioderma difforme.*

B. Special kinds of thallomes and specially differentiated parts of thallomes.

S. No. 141. With respect to various characters we may distinguish the following special kinds of thallomes:

1a. thallomes possessing active locomotion. See S. No. 142.
1b. unicellular thallomes with cell walls consisting of separate parts. See S. No. 143.
1c. special forms in the group of Bacteria. See S. No. 144.
1d. thallomes which may be considered colonies. See S. No. 145.
1e. compound thallomes or thallomes in the form of consortia. See S. No. 146.
1f. thalloid gametophytes: prothallium. See S. No. 147.
1g. more or less filamentous parts formed during the first developmental stages of germinating spores. See S. No. 148.
1h. thalloid sporophyte: sporogonium. See S. No. 149.
1i. podetia. See S. No. 150.
1j. sclerotia. See S. No. 151.
1k. fructifications. See S. No. 152.

S. No. 142. (cf. S. No. 141). Thallomes, including swarm spores and spermatozoids[1]) possessing active locomotion of all kinds (cf. S. No. 15). The majority of them are unicellular, although pluricellular motile thallomes with simple differentiation may occur, for instance *Planosarcina mobilis,* and even some which may be considered as colonies, for instance *Volvox globator* (see S. No. 145).

The following survey of terms available for organographical description of the several cases may be summed up here:

1a. in connection with amoeboid creeping movements.

Protoplasmic processes are often thrust out and are called pseudopodia (lobopodia of Zoology). *Myxomycetes* and many *Fungi,* the plano- or motile spores (cf. S. No. 84), appearing during the germination of their aplanospores.

1b. in connection with free swimming movements.

2a. cilia and flagella (cilium, flagellum). These terms designate vibratile protoplasmic processes of the outer surfaces of naked cells, either smaller and generally more numerous (cilia) or more whip-like and generally less numerous (flagella). They may be represented by undulating membranes *(Trypanosoma).* Swarm spores of all kinds, confer for examples S. No. 84; spermatozoids, confer for examples S. No. 123.

According to the number and distribution of cilia and flagella swimming cells may be designated as follows:

3a. monotrichous, with a single cilium or flagellum. *Vibrio cholerae; Chrysamoeba radians; Euglena gracilis.*

3b. ditrichous, with two cilia or flagella, sometimes of different length. *(Fucus,* spermatozoid; *Peridineae).*

4a. monopolar. Both cilia or flagella placed in close vicinity to one another. *Cryptomonas erosa; Chlamydomonas angulosa; Volvox globator; Marchantia* (spermatozoid).

4b. bipolar. Both cilia or flagella placed separately. *Biddulphia mobiliensis* (spore); *Pseudomonas ianthina.*

3c. polytrichous or polyciliate, with more than two, often numerous cilia.

4a. lophotrichous. The cilia are placed in tufts or in more extended groups.

5a. monopolar. There is only a single group of cilia, placed:

6a. at one of the ends. *Spirillum undula; Bulbochaete in-*

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[1]) In this article two kinds of naked protoplasts possessing active locomotion by means of cilia, namely swarm spores and spermatozoids have been inserted, although in the ordinary course of phytography they will not be called thallomes. On the other hand *Euglena viridis* for instance will readily be considered as belonging to thallomes, because its body represents the sole stage in which the species can appear, whilst swarm spores and spermatozoids are only ephemeral stages in the development of plants, exhibiting strongly differentiated forms of thallomes or even cormi. But swarm spores and spermatozoids require an organographical description as much as *Euglena* or other unicellular plants, like *Diatomaceae* etc. and having locomotion they may be considered along with motile thallomes.

termedia (swarm spores); *Ophioglossum* and *Cycas* (spermatozoids).

6b. laterally. *Cladotrix dichotoma* (swarm spores).

5b. bipolar. There are two groups of cilia. *Thiospirillum rufum.*

4b. peritrichous. Numerous cilia distributed over almost the whole surface. *Vaucheria sessilis* (swarm spores); *Bacillus subtilis.*

2b. eye spot (stigma). This term designates a small slightly protuberant spot of the surface, coloured red or brown and limited in its appearance to free swimming protoplasts. *Euglena viridis; Fucus,* spermatozoid.

S. No. 143. (cf. S. No. 141). In some unicellular thallomes the cell walls consist of two or more separate parts and here we may distinguish:

1a. the theca or armour (theca). The whole of the cell wall.

1b. valves or halves (valva). Two in *Diatomeae,* two or more in *Peridineae.*

N.B. In Diatomeae the structure being particularly complicated the following terms are in use to designate the different parts of the thallome and the directions in it.

1c. the epitheca. One half of the theca, which is slightly bigger than the other half and overlaps it by its edges like a lid may cover a box.

2a. epivalva. The central part of the epitheca.

2b. epipleura. The edge of the epitheca.

2c. copula. A more or less ring-shaped part between epivalva and epitheca.

1d. the hypotheca. The other half of the theca, fitting with its edge in the epitheca.

2a. hypovalva. The central part of the hypotheca.

2b. hypopleura. The edge of the hypotheca.

2c. copula. A more or less ring-shaped part between hypovalva and hypopleura.

1e. the raphe or middle suture. This is a linear part of one valve or of both valves, lying in the greatest diameter of the valve and exhibiting a peculiar structure. *Pinnularia viridis.*

1f. longitudinal axis, main axis, pervalvular axis or central axis. The line uniting the centres of the two valves.

1g. the sagittal axis or apical axis. A line perpendicular to the longitudinal axis, and parallel to the raphe or to the greatest diameter of the valves.

1h. the transversal axis or transapical axis. A line perpendicular to longitudinal axis and sagittal axis.

1i. the valvular plane, transverse plane or valvular view. The plane perpendicular to the main axis.

1j. the transapical plane or short girdle view. The plane perpendicular to the sagittal axis.

1k. the transvalvular plane, apical plane or long girdle view. The plane perpendicular to the transversal axis.

In some cases the axes and planes are curved, in other cases they may meet each other at skew angles. *Eucampia cornuta* (curved longitudinal axis), *Eunotogramma leavis* (curved sagittal axis), *Pleurosigma angulatum* (sagittal axis S-shaped), *Campylodiscus noricus* (sagittal and transversal axis concave at opposite sides of the main axis, *Campyloneis Grevillei* (sagittal and transversal axis concave at the same side of the main axis) ; *Surirella spiralis* (twisted along the sagittal axis), *Nitzschia palea* (valvular plane and transvalvular plane at skew angles).

S. No. 144. (cf. S. No. 141). In the group of Bacteria a certain number of terms is used designating the outward appearance of the body, often only dependent on external circumstances and bearing a morphological character. Nevertheless they have been used in many cases in a systematical sense for designating genera. As well-known morphological terms of this ambiguous kind we may distinguish:

1a. in unicellular forms with respect to shape.
  2a. coccus. Spherical; sometimes called micrococcus or macrococcus.
  2b. bacterium or bacillus. Cylindrical, not very long.
  2c. vibrio. Rod-shaped and slightly curved.
  2d. spirillum. Rod-shaped and more strongly curved.
  2e. spirochaete[1]). Filamentous and spirally wound.
1b. in pluricellular forms with respect to number and arrangement of cells.
  2a. cell divisions in a single direction.
    3a. diplococcus. Only two cells remaining together.
    3b. numerous cell divisions take place, so that filaments ensue.
      4a. filaments not enclosed within a sheath.
        5a. streptococcus.
      4b. filaments enclosed within a sheath; cells cylindrical.
        5a. leptothrix. Filaments unbranched.
        5b. cladothrix. Filaments exhibiting false branching.
  2b. cell division in two directions, at right angles to one another.
    3a. tetracoccus (merismopedia).
    3b. flat discs. Consisting of up to sixteen cocci.
  2c. cell division in three directions, at right angles with one another.
    3a. sarcine. Packets are formed, often composed of a large number of micrococci.
  2d. cell division in several irregular directions.
    3a. staphylococcus. Irregular clusters are formed.
1c. in unicellular forms with respect to enclosed endospores.

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[1]) Migula, System der Bacterien. Band I, Jena 1897, p. 151, expresses some doubt about the unicellular nature of spirochaete.

2a. clostridium. Oblong cell, with a thicker middle portion, containing the endospore.

2b. plectridium. Oblong cell, with one end thicker containing the endospore; the whole resembling a drum-stick.

S. No. 145. (cf. S. No. 141). Thallomes which may be considered colonies. They may exhibit the most various shapes, for instance that of a sphere *(Cladonia aegagropila; Volvox globator; Nostoc pruniforme,* etc.), that of a many-meshed cylindrical net *(Hydrodyction utriculatum),* that of a branching thallus *(Schizonema; Licmophora flabellata)* etc., for which no special terms are in use. Confer moreover S. No. 14.

Zoogloea is a term used for thallomes of this kind if the individuals lie embedded in a gelatinous mass. *Nostoc pruniforme, Leuconostoc, Kefyr.*

S. No. 146. (cf. S. No. 141). Compound thallomes or thallomes in the form of consortia. They consist of dissimilar thalloid organisms, living together in symbiosis and exhibit the forms of foliaceous, fruticose and crustaceous thalli, whilst some are gelatinous *(Collema).*

The most interesting example of this kind is afforded by Lichens and here we may distinguish as elements composing the consortium: 1. the body of a higher *Fungus,* mostly belonging to the *Ascomycetes,* sometimes to the *Basidiomycetes* and 2. the gonidia being unicellular or filamentous *Algae* belonging to the *Cyanophyceae* or *Chlorophyceae* and enclosed in the body of the *Fungus.* With respect to the reciprocal positions of *Fungus* and gonidia we may distinguish:

1a. the homoiomerous or unstratified thallus. The gonidia and fungal hyphae are uniformly distributed through the thallus. *Leptogium scotinum.*

1b. the heteromerous or stratified thallus. The gonidia are arranged in a definite layer and in this case we may distinguish:

2a. an epidermis, consisting of pseudo-parenchyma and on the under side of foliaceous thalli producing rhizines *(Sticta fuliginosa).*

2b. a rind, also consisting of pseudo-parenchyma and extending under the epidermis.

2c. the gonidial layer, flat in foliaceous thalli *(Sticta fuliginosa)* and more or less in the shape of a hollow cylinder in fruticose thalli *(Usnea barbata; Cladonia rangiferina,* podetia).

2d. the medullary tissue, consisting of true hyphae forming a medullary layer under the gonidial layer in foliaceous thalli *(Sticta)* or a medulla enclosed by the cylindrical gonidial layer in fruticose thalli *(Usnea).*

S. No. 147. (cf. S. No. 141). Thalloid gametophytes. Here we may distinguish:

1a. ordinary thalloid gametophytes. There is no contrast between gametophyte and sporophyte in so far as both exhibit a thalloid character. *Laminaria; Dictyota.*
1b. prothallium. This term designates an either foliaceous or tuberous, very seldom a filiform, thallus in those cases where the same plant in another stage of its developmental cycle exhibits a cormoid character. Examples: *Aspidium Filix mas,* foliaceous monoecious thallus; *Equisetum arvense,* foliaceous dioecious thallus; *Trichomanes,* filiform branched monoecious thallome, resembling the protonema of *Musci; Lycopodium,* tuberous monoecious thallus; *Gymnosperms,* endosperm, reduced female thallus within the embryosac (megaspore). See moreover M. N. No. 14.

S. No. 148. (cf. S. No. 141). Thalloid more or less filamentous parts formed during the first developmental stages of germinating spores. Throughout the vegetable kingdom, spores of all kinds, whether sexual (oospores) or asexual *(Ferns* and *Mosses),* haploid or diploid, do not tend at once to produce on germination the product which ultimately seems to be the most essential phase of their development. Thus in the first place a relatively slight preliminary part is formed, resulting in the first stage of a simple alternation of generations (cf. S. No. 25). These preliminary formations are mostly more or less filamentous; they may be unbranched or branched and in some cases may become plate-shaped. For products of this preliminary kind the following terms are used:
1a. protonema. This term designates a free growing product of the kind mentioned above; it may be strongly branched, in a few cases more or less plate-like; it produces laterally or terminally the second phase of the simple alternation of generations, consisting of one, several, or even a large number of more conspicuous plants. *Musci,* filamentous, strongly branched protonema, producing a large number of cormoid gametophytes; *Sphagna,* short, unbranched filamentous germ-tube expanding into a plate-like part, which produces one or more cormoid gametophytes; *Hepaticae,* reduced to a germ-tube; *Batrachospermum moniliforme,* filamentous branched protonema, arising from the carpospores and producing the essential phase of the plant; *Chara,* simple filamentous row of cells [1]), bearing laterally the fully developed phase of the plant.
1b. suspensor. This term designates a preliminary filamentous

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[1]) This protonema has been called a proembryo. But there are strong motives for dropping the term proembryo altogether in phytography. It has been used not only for the protonema of *Chara,* but also in two other cases: 1. for the product of the fertilised egg-cell in an archegonium before the differentiation of the embryo and 2. for the first developmental stages of the fertilised egg in the embryo sac of *Angiospermae* and *Gymnospermae* consisting of a row of cells (suspensor) and an apical cell giving rise to the embryo. It seems clear that a term of so uncertain a meaning cannot be maintained. Moreover in the case of *Chara* there does not exist a stage readily to be compared with an embryo, so that this term ought to be replaced by that of protonema, a term which in every respect seems suitable here, if defined as in the text.

part, not free growing, but developing by a kind of internal germination from a fertilised egg-cell, either within a free tuberous prothallium or within a prothallium which remains more or less enclosed in a megaspore (or embryo-sac) or even within a megaspore (embryo-sac) with a prothallium so strongly reduced as to become almost unrecognizable. It is the first product of the fertilised egg-cell and from its end cell the embryo developes.

Examples are to be found in many of the higher groups in the vegetable kingdom:

2a. *Pteridophyta.*

3a. some species of *Botrychium:* elongated, multicellular suspensor in a subterranean, saprophytic, tuberous free prothallium without chlorophyll, but inhabited by a mycorrhizal fungus.

3b. *Lycopodium:* pluricellular suspensor in free tuberous, often subterranean prothallium.

3c. *Selaginella:* pluricellular suspensor in a prothallium which remains for the greater part enclosed within the megaspore. *Isoetes* without suspensor.

2b. *Gymnospermae.*

3a. *Cycadinae:* pluricellular suspensor, in a prothallium (endosperm) which remains enclosed within the embryo-sac.

3b. *Ginkgoinae:* there is no clear division into suspensor and embryo.

3c. *Coniferae: Pinus austriaca,* pluricellular branched suspensor, producing more than one embryo in a prothallium (endosperm) which remains enclosed in the embryo-sac.

3d. *Gnetinae:* branched suspensor, producing its embryo within a prothallium.

2c. *Angiospermae:* a pluricellular suspensor, within a megaspore (embryo-sac) including no prothallium when the fertilised egg-cell begins its development.

1c. promycelium or promycele. This term designates a preliminary filament of hyphal origin, short-lived and ending in the production of sporidia. (cf. S. No. 87). *Puccinia graminis,* germination of teleutospores.

S. No. 149. (cf. S. No. 141). Thalloid sporophytes. Here we may distinguish:

1a. ordinary thalloid sporophyte. There is no contrast between gametophyte and sporophyte in so far as both exhibit a thalloid character. *Laminaria, Dictyota.*

1b. sporogonium. This term designates a sporangium (cf. S. No. 98) representing a complete sporophyte in cases where the same plant exhibits in the gametophyte a cormoid character. *Bryophyta.*

S. No. 150. (cf. S. No. 141). Podetia. This term designates erect fruticose thalli arising by simple alternation of generations from small horizontal crustaceous thalli which soon disappear. They may have various shapes, some are slender and cylindrical, simple or forked, others are stalked and funnel-shaped, others again are finely branched. They often bear knob-like apothecia which in the funnel-shaped ones appear on the margin or outgrowths of it *(Cladonia pyxidata)* and in the finely branched ones at the ends of the branches *(Cladonia rangiferina)*.

S. No. 151. (cf. S. No. 141). Sclerotium. This term designates thallomes or parts of them which have passed into a resting stage and contain abundance of nutritive substances in a dry state. They are compact spherical, oblong, irregular or strand-like bodies, sometimes forming a reticulate mass; they often are darkly coloured; by the influence of suitable stimuli they may return to active life. *Barbula* and *Funaria*, tubers of the rhizoids; *Fuligo varians* and many other *Myxomycetes; Claviceps purpurea, Coprinus stercorarius, Agaricus melleus* and many other *Fungi*. Sclerotia belonging to *Fungi* are composed of pseudo-parenchyma and the strand-like forms among them, like those of *Agaricus melleus*, were often called by the name of rhizomorpha. The term microcyst is used for a sclerotium arising from a single amoeboid cell *(Chondrioderma difforme)*, that of macrocyst designates a sclerotium arising from a very small plasmodium *(Fuligo varians)*.

S. No. 152. (cf. S. No. 141). Concerning thalloid fructifications the following subjects will be dealt with:
1a. peridium. See S. No. 153.
1b. kinds of thalloid fructifications. See S. No. 154.
1c. distribution of hymenia in thalloid fructifications. See S. No. 173.

S. No. 153. (cf. S. No. 152). Peridium. This term is often used in describing thalloid fructifications and indicates a sterile outer enveloping layer which often completely, in other cases partly, surrounds the fertile part of those fructifications which exhibit a more or less compact shape. See S. No. 169. *Erysiphae; Lycoperdon; Phallus; Verrucaria; Characeae,* envelopes of globules and nucules. The term volva or velum universale is often used, if the fructification is one of larger size. See S. No. 168 and 169.

S. No. 154. (cf. S. No. 152). With respect to shape we may distinguish the following kinds of thalloid fructifications:
1a. purely asexual.
  2a. thalloid gemmiferous receptacles or gemma-cups. See S. No. 155.
  2b. coremia. See S. No. 156.
  2c. spore-beds (comprising the terms sporodochia and acervuli). See S. No. 157.
1b. fructifications more or less in relation to sexual reproduction.
  2a. aethalia and simpler fructifications, arising by metamorphosis from plasmodia. See S. No. 158.
  2b. fructifications containing conceptacula. See S. No. 159.

2c. cystocarps provided with a pericarp. See S. No. 160.
2d. globules. See S. No. 161.
2e. nucules. See S. No. 162.
2f. apothecia. See S. No. 163.
2g. perithecia and stromata. See S. No. 164.
2h. aecidia. See S. No. 165.
2i. fructifications of the higher Fungi, Hymenomycetes and Gasteromycetes. See S. No. 166.
2j. spermogonia, pycnidia. See S. No. 170.
2k. marsupium. See S. No. 171.
2l. thalloid male and female receptacles. See S. No. 172.

S. No. 155. (cf. S. No. 154). Thalloid gemmiferous receptacles or gemma-cups. They are outgrowths of the upper side of a thallus, cup-shaped or crescent-shaped, producing on their bottom a hymenium consisting of gemmae which may exhibit a lenticular shape, and further between these gemmae club-shaped paraphyses. *Marchantia polymorpha; Lunularia vulgaris.*

S. No. 156. (cf. S. No. 154). Coremia. This term designates tuftlike fructifications producing conidia. *Chaetomium Boulangeri; Isaria farinosa.*

S. No. 157. (cf. S. No. 154). Spore-beds (comprising the terms sporodochia and acervuli[1])). This term designates fructifications in the shape of layers producing conidia; they are flat, although in some cases they may exhibit at their margins a certain tendency to be raised. *Gloeosporium fructigenum.*

S. No. 158. (cf. S. No. 154). Aethalia[2]) and more simple fructifications, arising by metamorphosis from plasmodia. In their simplest form they are stalked, often spherical, cylindrical or club-shaped capsules exhibiting a closed peridium; they contain spores and a sterile part. The term aethalium (Rostafinski) designates large fructifications produced by the coalescence of several or even a very great number of simple ones. The sterile parts of the contents may consist of:
1a. a capillitium. A system of threads reticulately united together forming a scaffolding among the spores. *Bartramia.*
1b. cellular elaters. Intermixed with the spores, parenchymatous or prosenchymatous. *Trichia varia.* Confer also S. No. 114.

Further examples are: *Arcyria punicea* and *Leocarpus fragilis* (simple fructifications); *Fuligo varians* (large aethalia).

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[1]) These terms may be considered obsolete, although they are sometimes still used in senses somewhat different from the original, in which sporodochia designates spore-beds in a saprophytic plant and acervuli the same in a parasitic plant.

[2]) The term aethalium was formerly used as the name of a distinct genus, for instance *Aethalium septicum*, which is now called *Fuligo varians*. Thus the term originally had no morphological character.

S. No. 159. (cf. S. No. 154). Fructifications containing conceptacula. They are the swollen tips of a thallus, exhibiting numerous deep flask-shaped depressions of the surface, called conceptacula. At the bottom of these, there is a hymenium consisting of gametangia; oogonia and antheridia either both together or only of one kind. This hymenium is intermixed with many paraphyses, often protruding in tufts from the mouth of the conceptacle. *Fucus platycarpus,* monoecious; *Fucus vesiculosus,* dioecious.

S. No. 160. (cf. S. No. 154). Cystocarps provided with a pericarp. The term cystocarp designates the products of sexual reproduction in *Florideae* and among them some are devoid of an envelope of vegetative origin, so that they cannot be considered as fructifications. *Nemalion multifidum* is an example of this kind. Limiting ourselves here to those cystocarps which exhibit an envelope of vegetative origin, we may say that they are more or less closed fructifications, of simple somewhat spherical, oblong or short cylindrical shapes, sometimes sunk in the thallus which produces them; they contain clusters of carpospores (cf. S. No. 130); there is a surrounding envelope called peridium or pericarp having a simple structure; the carpospores arise from carpogonia (cf. S. No. 128), the peridium from vegetative cells below the carpogone. *Polysiphonia; Ceramium; Gigartina mamillosa; Chondrus crispus,* sunk in the thallus.

S. No. 161. (cf. S. No. 154). Globules of Characeae[1]). They are spherical, strongly coloured, male fructifications of a rather complicated structure, exhibiting a peridium within which there are enclosed eight sori of naked plurilocular antheridia. In the globule we may distinguish:
1a. a central cell. This is a basal flask-shaped cell entering into the lower part of the internal cavity and reaching about to its centre. In *Nitella* a flat cell is formed by a division at the top of the stalk cell.
1b. eight shields (scutum). They are flat curved cells forming the outer wall of the globule, four of them being triangular and forming the upper part of the wall, the lower ones being four-angled and a little narrowed below leaving passage for the stalk cell.
1c. eight manubria or handles (manubrium). They are cylindrical cells projecting inwards, one from the centre of the inner cell wall of each shield, almost as far as the centre of the hollow sphere.
1d. eight head-cells (capitulum). One at the central extremity of each manubrium and uniting it to the top of the stalk cell, so that the frame work of the globule is essentially composed of twenty-five cells.

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[1]) In literature the terms antheridium and oogonium are mostly used for designating globule and nucula, but from what has been mentioned in the text it seems evident that such a use of the former terms ought to be avoided.

1e. eight groups of from three to eight, mostly six secondary head-cells, each arising from one of the head-cells and each producing:
1f. three to five, often four naked plurilocular antheridia in the shape of long filaments consisting of a row of many (up to 225) disciform cells producing spermatozoids.

S. No. 162. (cf. S. No. 154). Nucules, sporophyades, sporophydia or spore-buds of Characeae (nuculus). They are female fructifications consisting of the following parts:
1a. a stalk cell. A basal cell, often short and even not easily distinguishable *(Chara)*.
1b. the sporostegium or peridium (sporostegium). This is an envelope of the oogonium, consisting of five spirally twisted tubes; it arises from a single cell which is a sister cell of the stalk cell, placed above it; and it produces by cell budding at its circumference five cylindrical cells forming the envelope; cell division takes place at the top of each tube and thus there appears:
2a. a coronule (coronula). This is a body crowning the nucule and consisting of five or ten cells according to the formation of a single *(Chareae)* or of two *(Nitelleae)* shorter cells at the top of each tube.
1c. the oogonium. This contains only a single egg-cell and exhibits during its development the formation of so-called turning cells (German: Wendungszellen or Wendezellen), which are elements of most uncertain nature; in ripe *Nitelleae* there are three of these cells, one at the top, one in the middle part and one at the base of the oogonium, but as they belong to a very early stage of development and do not partake of the somewhat oblique growth of the oogonium itself, they remain at the base of it and even may have disappeared in the ripe oogonium: in *Chara* however there is only a single cell of this kind appearing at a somewhat later stage of development at the base of the oogonium and remaining there more or less distinguishable.

S. No. 163. (cf. S. No. 154). Apothecia. They are open saucer-, cup-, bowl-, club-, knob- or hat-shaped fructifications, the free upper or lateral surface being covered with a hymenium, which consists of a single layer of asci and is intermixed with paraphyses, a peridium may be wanting, but in most cases laterally surrounds the margin of the hymenium, without covering it. Apart from the frequent case of apogamy, the asci arise from ascogonia, (cf. S. No. 128) which produce ascogenous filaments bearing the asci on their ultimate ramifications; the basal part of the fructifications, its peridium and paraphyses are formed by vegetative hyphae below the ascogonium. Apothecia are produced by mycelia or thalli. *Peziza, Xanthoria parietina.*

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1) Rabenhorst. 2nd ed, II, Hauch. Die Meeresalgen, Leipzig 1885, p. 11.

S. No. 164. (cf. S. No. 154). Perithecia. They are closed, more or less spherical or flask-shaped fructifications, either surrounded by a complete investing peridium or showing an aperture at the top and then resembling conceptacles (cf. S. No. 159); they contain one or more asci mostly forming a hymenium at the base of the cavity, paraphyses often being present, sometimes periphyses also (see S. No. 450, S. No. 738); they arise from a mycelium or a thallus. *Nectria, Sphaeria, Erysibe* (closed peridium); *Endocarpon* and *Verrucaria* (flask-shaped with an aperture).

In some cases a certain number of perithecia appears in a group, embedded in a compact mass of tissue, mostly consisting of pseudoparenchyma. The term stroma is used for such masses, which exhibit various shapes and may be branched. *Claviceps purpurea* (stromata arising from sclerotia and having a capitate shape. See also S. No. 170.

S. No. 165. (cf. S. No. 154). Aecidia. They are cup-shaped, when young closed and globular fructifications; at their base there is a hymenium consisting of numerous cells, each abstricting a chain of spores; the peridium mostly is formed by thick-walled cells, corresponding to sterile peripheral rows of spores; they arise from mycelia which grow in intercellular spaces. *Puccinia graminis; Phragmidium violaceum.*

S. No. 166. (cf. S. No. 154). Fructifications of the higher Fungi, Hymenomycetes and Gasteromycetes. They show many different shapes and may be very massive, so that even annual layers may occur in certain parts *(Polyporus fomentarius,* tubes containing hymenia). In *Gasteromycetes,* for instance *Lycoperdon,* they show often a simple construction, consisting only a thick peridium, covering the internal hymenial portion, called gleba.

Among these fructifications with respect to their shape the following kinds may be distinguished:

1a. crustaceous fructifications of Hymenomycetes. Bearing the hymenium on their smooth upper surface, or the incrustations become raised above the substratum, thus forming bracket-like projections often showing an imbricate arrangement and with the hymenium on the under side. *Thelephoreae, Stereum hirsutum.*

1b. fruticose fructifications of Hymenomycetes. They are erect, club-shaped, cylindrical or ribbon-like and often profusely branched in a more or less coral-like fashion. *Clavaria botrytis* and *Sparassis crispa.*

1c. capitate fructifications. Here we may distinguish:

2a. a stalk or stipe. This is a sterile, more or less cylindrical, often large and well-developed basal part which may however be wanting in some cases.

2b. a pileus or cap. This is the reproductive laterally more or less extending part, borne at the top of the stalk. See moreover S. No. 167.

S. No. 167. (cf. S. No. 166). Concerning capitate fructifications the following subjects will be dealt with:
1a. their development. See S. No. 168.
1b. terms related to complicated capitate fructifications. See S. No. 169.

S. No. 168. (cf. S. No. 167). Capitate fructifications occur in various kinds with respect to their origin:
1a. they represent a complete fructification. *Morchella; Helvella; Psalliota campestris.*
1b. they represent only the inner part of a fructification and in an early phase of their development are covered with a peridium often called volva. *Phallus; Amanita muscaria.* See S. No. 169.
1c. they represent a stroma containing numerous perithecia in their pileus. *Claviceps purpurea.* (cf. S. No. 164).

S. No. 169. (cf. S. No. 167). In more complicated capitate fructifications of various kinds we may distinguish beside stalk and pileus:
1a. a gleba. (cf. S. No. 166). Sometimes covering the surface of the pileus. *Phallus.*
1b. a peridium *(Phallus),* called in other cases volva or velum universale. It is a closed envelope which is ruptured during further development of stalk and pileus and thus in its remnants may give rise to:
  2a. a sheath or ring at the base of the stalk. *Amanita bulbosa.*
  2b. scales. Often numerous and in consequence of the growth of the pileus separated from one another on its upper surface. *Amanita muscaria.*
1c. a velum partiale. This is a thin membrane extending in young capitate fructifications from the stalk to the margin of the pileus; in consequence of the growth of the pileus in a horizontal direction the membrane is torn and may give rise to:
  2a. an annulus. The remains of the velum encircle the stalk like a frill. *Psalliota campestris; Amanita bulbosa.*
  2b. a cortina. The velum partiale separates entirely from the stalk and hangs as a membranous curtain torn into filamentous shreds from the margin of the pileus.
1d. the parts which bear the hymenium and occur at the under side of the pileus chiefly as:
  2a. conical or spinous projections. *Hydnum.*
  2b. tubes, sunk in the pseudo-parenchyma. *Polyporus.*
  2c. lamellae or gills. Radially arranged perpendicular lamelliform projections, of which the body within the hymenium is called trama. *Psalliota campestris.*

S. No. 170. (cf. S. No. 154). Spermogonia, pycnidia. They are spherical or flask-shaped bodies sunk in a thallome, sometimes in the apex of special short cilia or produced by a mycelium growing in the intercellular spaces of a host-plant; from the surface of their inner cavity arise gametophores or conidiophores abstricting spermatia or pycnospores. *Anaptichia ciliaris, Cetraria islandica* and *Puccinia graminis* (on *Berberis),* spermogonia; *Cryptospora hypodermia* and *Strickeria obducens,* pycnidia.

In some cases a certain number of spermogonia or pycnidia appears in a group embedded in a compact mass of tissue mostly consisting of pseudo-parenchyma. The term stroma is used for such masses as well as for those enclosing perithecia (cf. S. No. 164), of which *Valsa leucostoma* affords an example. Sometimes both spermogonia and perithecia may occur successively in the same stroma.

S. No. 171. (cf. S. No. 154). Marsupium. This is a pouch-like wall surrounding and arching over a few archegonia sunk in the upper surface of a thallus. When the sporogonia developed from the archegonia elongate, it is ruptured and forms a sheath at their base. *Anthoceros.*

S. No. 172. (cf. S. No. 154). Thalloid male and female receptacles. They are erect branches of the thallus and may be composed of the following parts:

1a. a stalk. A more or less cylindrical basal part expanding at its top into:

1b. a disciform part, which may be more or less branched.

2a. male discs bearing the antheridia on their upper sides in flask-shaped depressions, each containing one antheridium and communicating with the outer world by means of a narrow canal.

2b. female discs which also may be branched and may bear relatively much larger radially expanding branches between which the archegonia seem to appear at the under side of the disc. The archegonia may be then arranged in rows between the rays, each row being enveloped by a sheath-like toothed involucre or perigynium.

A very complete example of the above structure is afforded by *Marchantia polymorpha.*

S. No. 173. (cf. S. No. 152). Hymenia (cf. S. No. 132) play an important part in the formation of many thalloid fructifications. They may extend over external surfaces or over the surfaces of certain internal cavities. The principal cases occurring here are that the hymenium covers:

1a. the upper or under surface of very simple fructifications. *Thelephoreae, Stereum hirsutum.*

1b. the smooth outer surface of more complex fruticose fructifications. *Clavaria botrytis.*

1c. the reticulately indented exterior surface of the pileus of certain capitate fructifications of Hymenomycetes. *Morchella esculenta.*

1d. spinous projections of certain fructifications, either from the upper side of incrustations or from the under side of a pileus. *Hydnum imbricatum.*
1e. the surfaces of pit-like depressions, deep winding passages or the inside of narrow dependent tubes on certain fructifications, either on the under side of bracket-shaped forms *(Daedalia quercina)* or on the under side of a pileus *(Boletus edulis; Polyporus fomentarius).*
1f. lamellae or gills. Thin vertical radially arranged plates hanging from the under side of the pileus of certain capitate fructifications of Hymenomycetes. *Agaricineae, Psalliota campestris.*
1g. the surface of the walls of internal and closed chambers in the gleba of certain tuberous fructifications. *Lycoperdon; Bovista.*
1h. the surfaces of the walls of internal passages which have outlets on the exterior surface of certain tuberous fructifications. *Tuber cibarium.*
1k. the upper surface of cup-shaped or the outer surface of knob-shaped apothecia. *Xanthoria parietina; Peziza; Cladonia pyxidata.*
1l. the basal part of the inner surface of perithecia, conceptacula and aecidia. *Claviceps purpurea,* perithecia; *Fucus platycarpus,* conceptacula; *Puccinia graminis,* aecidia.
1m. the bottom of thalloid gemma-cups. *Marchantia polymorpha.*
1n. the upper surface of spore-beds. *Gloeosporium fructigenum.*
1o. the internal surface of spermogonia and pycnidia. *Cryptospora hypodermia; Strickeria obducens; Puccinia graminis.*

§ 2. Cormus and its constituent parts: caulome and phyllome.

A. Caulome. Confer for the signification of this term S. No. 73.

1. General description.

S. No. 174. Concerning the general description of a caulome the following subjects will be dealt with:
1a. life-time. See S. No. 175.
1b. medium in which they live. See S. No. 176.
1c. direction of caulomes. See S. No. 177.
1d. direction of branches and branchlets. See S. No. 178.
1e. shape of transverse section. See S. No. 179.
1f. character of the surface. See S. No. 180.

S. No. 175. (cf. S. No. 174). With respect to its life-time the caulome may be:
1a. annual. *Papaver Rhoeas; Urtica dioica,* aerial caulome; *Beta vulgaris,* caulome of the second year.
1b. biennial. *Rubus Idaeus,* aerial caulomes; *Lunaria annua (L. biennis)* and *Beta vulgaris,* the caulome of the first year.
1c. perennial. With a relatively unlimited life-time. *Urtica dioica* and *Rubus Idaeus,* subterranean caulomes; trees and shrubs.

S. No. 176. (cf. S. No. 174). With respect to the medium in which they live caulomes may be:
1a. aerial. All trees.
1b. submerged. *Potamogeton.*
1c. subterranean. See S. No. 188.

S. No. 177. (cf. S. No. 174). With respect to their direction caulomes may be:
1a. erect (erectus). Growing perpendicularly upwards. *Senecio vulgaris.*
1b. hanging down (dependens, pendulus). Hanging perpendicularly downwards. *Linaria Cymbalaria.*
1c. procumbent (humifusus). Lying horizontally on the soil. *Polygonum aviculare; Illecebrum verticillatum.*
1d. ascending (adscendens). Basal part procumbent, apical part erect. *Reseda odorata; Potentilla palustris (Comarum palustre).*
1e. drooping (cernuus). Erect, but the apical part horizontally inclined. *Dahlia* and *Helianthus annuus.*
1f. nodding (nutans). Erect, but the apical part hanging down. *Fritillaria Meleagris; Papaver Rhoeas,* when the flower is still a bud.
1g. climbing (scandens). Having no direction of their own, but following that of some support, to which they are attached in various ways. *Hedera Helix; Cucurbita Pepo; Ampelopsis hederacea; Tropaeolum majus; Rubus* spp.; *Galium aparine.*
  2a. twining (volubilis). Spirally winding round a support. (cf. S. No. 75).
    3a. sinistrorse[1]) or to the left (sinistrorsum volubilis). For a person placed within the spiral ascending to the left; the most general case. *Calystegia sepium (Convolvulus sepium).*
    3b. dextrorse or to the right (dextrorsum volubilis). For a person placed within the spiral ascending to the right. *Humulus Lupulus; Lonicera Periclymenum; Testudinaria elephantipes* (branches).

In the genus *Dioscorea* some species twine sinistrorse, others dextrorse; in the species *Solanum Dulcamara* some individuals are sinistrorse, others dextrorse; in *Muehlenbeckia varians* [2]), *Loasa aurantiaca,* etc. the same individual may have both sinistrorse or dextrorse caulomes.

S. No. 178. (cf. S. No. 174). With respect to their direction branches and branchlets (small branches) may be:
1a. fastigiate (fastigiatus). Directed perpendicularly upwards. *Populus pyramidalis.*
1b. horizontal (horizontalis). *Picea excelsa.*

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[1]) De Candolle, La phytographie, Paris 1880, p. 201. Th. Schmucker, Rechts- und Linkstendenz bei Pflanzen, Beihefte zum Botanischen Centralblatt, 41, erste Abteilung 1924, p. 51 pleads for the reverse definitions.

[2]) Linné used here the name of a statesman whom he disliked and who had changed his political opinions.

1c. spreading (patens). Forming an angle of about 45° with the apical part of its podium. *Fagus sylvatica.*
1d. pendulous (pendulus). Directed perpendicularly downwards. Weeping trees: *Salix babylonica, Fraxinus excelsior,* var. *pendula.*
1e. inclining (declinatus). Base spreading, at the apex inclining. *Betula alba.*

S. No. 179. (cf. S. No. 174). With respect to the shape of its transverse section the caulome may be:
1a. terete (teres). Cylindrical. *Conium maculatum; Phragmites communis.*
1b. angular (angularis). More or less prismatical; according to the number of sides of the prism we may use the terms triangular (triangularis), quadrangular (quadrangularis), quinquangular (quinquangularis) up to multangular (multangularis). *Phyllocactus; Carex; Lamium album; Cucurbita Pepo; Vaccinium Myrtillus.*

S. No. 180. (cf. S. No. 174). With respect to the character of the surface the caulome may be:
1a. smooth (laevis). *Conium maculatum.*
1b. costate (costatus). Exhibiting longitudinal, broad, more or less cuneiform, protruding ribs at a relatively large distance from one another. *Melocactus.*

In many cases the caulome shows a limited number of more or less prominent ribs or ridges, which correspond to the downward decurring lateral margins of the insertion, or to the decurring midribs of the phyllomes of the cormus. The number of these ridges therefore depends on the phyllotaxy of the cormus-individual. *Jasminum fruticans,* usually five ribs [1]); *Labiatae,* usually four ribs corresponding to the lateral margins of the decussate phyllomes; *Stellatae,* usually four ribs corresponding to the midribs of the decussate phyllomes. These ridges may be provided with a laminar outgrowth in continuation of the decurrent leaf, so that the caulome becomes winged. *Lathyrus odoratus* (see S. No. 198).

1c. furrowed (sulcatus). Exhibiting numerous longitudinal narrow ribs at a small distance from one another, so that the furrows attract more attention. *Equisetum palustre.*

2. Special kinds of caulomes and specially differentiated part of caulomes.

S. No. 181. Concerning special kinds of caulomes and parts of them the following subjects will be dealt with:
1a. stem. See S. No. 182.
1b. trunk. See S. No. 183.

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[1]) G. van Iterson Jr., Mathematische und mikroskopisch-anatomische Studien über Blattstellungen etc, Jena 1907, where much information is to be found on lineated stems in the Chapter Zeichnung und Form des reifen Stengels, p. 230.

1c. culm or straw. See S. No. 184.
1d. calamus. See S. No. 185.
1e. creeping caulome. See S. No. 186.
1f. rhizome. See S. No. 187.
1g. caudex or stock. See S. No. 188.
1h. hypocotyl and epicotyl. See S. No. 189.
1k. disc. See S. No. 190.
1l. tubers. See S. No. 191.
1m. spines representing caulomes. See S. No. 192.
1n. tendrils representing caulomes. See S. No. 193.
1o. parts of caulomes belonging to fructifications. See S. No. 194.

S. No. 182. (cf. S. No. 181). Stem (caulis). This term designates all herbaceous caulomes including those which, devoid of foliage leaves, have the function of carbon assimilation, like *Sarothamnus* or succulent stems of *Cacti* and *Euphorbia.* Woody caulomes may be called stems if they are thin.

S. No. 183. (cf. S. No. 181). Trunk (truncus). This term designates the woody main stem of a tree. (cf. S. No. 12). *Quercus sessilis; Cocos nucifera.*

S. No. 184. (cf. S. No. 181). Culm or straw (culmus). This term designates an unbranched caulome with very distinct internodes and nodes, the former with a few exceptions *(Saccharum officinarum; Zea Mais)* hollow, the latter often somewhat thickened; it is mostly herbaceous, although in some cases woody. *Bambusa.*

S. No. 185. (cf. S. No. 181). Calamus (calamus). This term designates a caulome principally formed by a single long internode; it is devoid of foliage leaves, unbranched, herbaceous, green and having the function of carbon assimilation. *Juncus conglomeratus; Scirpus lacustris.*

S. No. 186. (cf. S. No. 181). Creeping caulome (caulis repens). This term designates a procumbent caulome, which is attached to the soil by means of roots arising from the nodes. *Nepeta Glechoma (Glechoma hederacea); Ajuga reptans.*

S. No. 187. (cf. S. No. 181). Rhizome (cf. S. No. 75) when the phyllomes of it are developed into foliage leaves, so that the subterranean part represents only the caulome. See moreover S. No. 277. *Pteris aquilina; Aspidium Filix mas.*

S. No. 188. (cf. S. No. 181). Caudex or stock (caudex). This term designates the subterranean, mostly perpendicular, basal part of a caulome consisting of short internodes and persisting after the aerial parts of the caulome have decayed; thus having lost its foliage leaves, which form a radical rosette, it enables the plant to hibernate and to become perennial; at its base it is always provided with one or more roots, as in some cases the primary root remains *(Taraxacum officinale)* or soon decays and is replaced by adventitious roots, often of considerable dimensions *(Valeriana dioica);* it often produces buds, thus becoming more or less ramified and when the original caudex dies, new ones may be formed from the buds; it is mostly not dorsiventral. Additional examples are afforded by *Rheum officinale* and *Polygala Senega.*

S. No. 189. (cf. S. No. 181). We may distinguish:
1a. the hypocotyl (internodium hypocotylum). This term designates the part of the caulome between root and cotyledons; the transition between hypocotyl and root is mostly gradual and the substitution of caulome structure by root structure in different tissues may take place at different levels.
1b. the epicotyl (internodium epicotylum). This term designates the first internode above the cotyledons.

S. No. 190. (cf. S. No. 181). Disc (discus). This term designates the caulome of a bulb. See S. No. 285.

S. No. 191. (cf. S. No. 181). Tubers representing caulomes. (cf. S. No. 75). *Nephrolepis tuberosa* [1]), tubers at the apices of subterranean runners; *Equisetum arvense,* tubers representing single internodia of the rhizome.

S. No. 192. (cf. S. No. 181). Spines representing caulomes. (cf. S. No. 75.) They are provided with a subtending phyllome, and may sometimes produce phyllomes and even flowers. *Gleditschia triacanthos; Crataegus oxyacantha; Prunus spinosa; Hippophaë rhamnoides.*

S. No. 193. (cf. S. No. 181). Tendrils representing caulomes; stem tendrils. (Cf. S. No. 75). They often replace flowers or inflorescences. *Passiflora coerulea; Vitis vinifera* (cf. S. No. 63); *Vitis hederacea (Ampelopsis hederacea).*

S. No. 194. (cf. S. No. 181). Parts of caulomes belonging to fructifications. Here we may distinguish:
1a. pseudopodium. See S. No. 195.
1b. scape. See S. No. 306.
1c. peduncle of an inflorescence (pedunculus). See S. No. 306.
1d. pedicels of an inflorescence (pedicellus). See S. No. 306.
1e. receptacle of a flower (receptaculum). See S. No. 319.

S. No. 195. (cf. S. No. 194). Pseudopodium. This term designates an apical prolongation of a caulome having a tendency to expand at its top, where it contains the foot of a sporogonium, for which the pseudopodium serves as a stalk. *Sphagnum; Andraea.*

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[1]) Velenovsky, Vergl. Morph. d. Pflanzen. Prag. 1905, I. p. 157.

B. Phyllome. Confer for the signification of this term S. No. 73.

1. General description.

S. No. 196. Concerning the general description of phyllomes the following subjects will be dealt with:
1a. the phyllome proper. See S. No. 197.
1b. stipular parts of the phyllome. See S. No. 221.

S. No. 197. (cf. S. No. 196). In phyllomes we may distinguish the following parts:
1a. the sheath or leaf-sheath (vagina). It is a more or less flattened basal part which more or less surrounds the caulome; no special technical terms are in use for it, so that for each case a particular description should be made.
1b. the petiole or leaf-stalk (petiolus). It is mostly rod-shaped and may swell at its base into a leaf-cushion or pulvinus *(Leguminosae)*. In the case of a complete phyllome it is placed at the top of the sheath and bears at its own top the blade. See S. No. 198.
1c. the blade (lamina). It is flat and generally the principal part.
It has a tendency to ramification which may appear in various degrees and with respect to this character we may distinguish:
2a. simple phyllomes (simplex). The blade may be unbranched, slightly, up to much or repeatedly branched, but always so that the blade appears as a single coherent mass. See S. No. 199.
2b. compound phyllomes (compositus). The blade is always branched in such a way that there seems to be a certain number of separate simple blades connected together by rod-shaped parts resembling petioles. See S. No. 216.

S. No. 198. The insertion of a phyllome may be:
1a. without petiole.
2a. sessile phyllome (sessilis). Petiole simply wanting. *Myosotis palustris,* foliage leaf.
2b. stem-clasping phyllome (amplexicaulis). The lateral basal parts of a phyllome partly surround the caulome. *Sonchus oleraceus,* foliage leaf.
2c. perfoliate phyllome (perfoliatus). The lateral basal parts of a phyllome coalesce around the caulome. *Bupleurum rotundifolium,* foliage leaf.
2d. connate phyllomes (connatus). The bases of two or more phyllomes inserted at the same level on the caulome coalesce. *Lonicera Caprifolium, Claytonia perfoliata, Dipsacus sylvestris, Scabiosa Succisa (Succisa pratensis)*, foliage leaves.
2e. decurrent phyllome (decurrens). The lateral basal parts of a phyllome extend downwards right and left of its insertion, forming wings on the caulome. *Verbascum thapsiforme,* foliage leaf.
1b. petiolate (petiolatus).

In this case the petiole may be:
2a. ordinary or rod-shaped. *Acer Pseudo-Platanus,* foliage leaf.
2b. winged (alatus). It has a flat shape. *Citrus Aurantium,* foliage leaf.
2c. phyllodium (phyllodium). Like the winged petiole, but mostly without blades and replacing them in their function. *Leacaena (Acacia) diversifolia, Lathyrus aphaca,* foliage leaves.

S. No. 199. (cf. S. No. 197). In the blade of a simple phyllome we may distinguish:
1a. the outline (circumscriptio). See S. No. 200.
1b. the apex (apex). See S. No. 205.
1c. the base (basis). See S. No. 206.
1d. the veins (nervus). They are those parts of the blade which contain the meristeles; in general they are strongly ramified with numerous anastomoses and extend through all parts of the blade; they are not rich in chlorophyll and in many cases contain thick-walled cellular elements; they often are prominent on the under side of the blade, with a corresponding depression on the upper side. The terms venation, nervation or nervature designate the mode in which the veins are arranged in the blade. See S. No. 207.
1e. the intervenia (intervenium). The areas of tissue filling up the spaces between the veins; they chiefly consist of parenchymatous tissues and often contain much chlorophyll.
1f. the margin (margo). See S. No. 210.

S. No. 200. (cf. S. No. 199). With respect to the outline it is of much importance in which part of the length the broadest part of the blade occurs. This may be:
1a. in the middle part. (See S. No. 201).
1b. towards the base. (See S. No. 202).
1c. towards the apex. (See S. No. 203).
1d. the greatest breadth extends almost over the whole length. See S. No. 204.

S. No. 201. (cf. S. No. 200). The broadest part of the blade occurs in the middle. The blade then may be:
1a. orbicular (orbicularis). Length and breadth are the same. *Lysimachia Nummularia, Rhus Cotinus,* foliage leaves.
2a. peltate (peltatus). Orbicular but fixed to the petiole by the centre or by some point distinctly within the margin. *Tropaeolum majus, Hydrocotyle vulgaris,* foliage leaves.
1b. oval (ovalis) or elliptical (ellipticus). Length surpassing the breadth one and a half times. *Symphoricarpus racemosus, Cornus sanguinea, Fagus sylvatica,* foliage leaves.
1c. oblong (oblongus). Length surpassing the breadth two and a half times. *Ficus elastica, Aucuba japonica,* foliage leaf.

1d. lanceolate[1]) (lanceolatus). Length surpassing the breadth three to five times. *Salix alba,* foliage leaf.

S. No. 202. (cf. S. No. 200). The broadest part of the blade occurs towards the base. The blade then may be:
1a. ovate or egg-shaped (ovatus). *Syringa vulgaris, Stellaria media,* foliage leaves.
1b. triangular (triangularis). It has the shape of an isosceles triangle. *Atriplex hortensis,* foliage leaf.
1c. deltoid (deltoideus). It has the shape of an equilateral triangle. *Populus monilifera, Tetragonia expansa,* foliage leaves.
1d. rhomboid (rhomboideus). It has more or less the shape of a rhomb. *Betula alba, Populus pyramidalis,* foliage leaves.

S. No. 203. (cf. S. No. 200). The broadest part of the blade occurs towards the apex. The blade then may be:
1a. obovate ((obovatus). Egg-shaped, but with the broad end towards the top. *Vaccinium Myrtillus, Corylus avellana,* foliage leaves.
1b. spatulate (spathulatus). Obovate, but the blade extends downwards into a long narrow part. *Bellis perennis,* foliage leaves.
1c. wedge-shaped (cuneatus). Inversely triangular. *Ginkgo biloba,* foliage leaves.
1d. obcordate (obcordatus). Inversely cordate, showing a notch at the apex. (See S. No. 215). *Oxalis* spp., leaflets.

S. No. 204. (cf. S. No. 200). The greatest breadth extends almost over the whole length.
The blade then may be:
1a. linear (linearis). The transverse section is flat. *Taxus baccata, Gramineae, Hippophaë rhamnoides,* foliage leaves.
2a. strap-shaped (ligulatus). Linear, but very long, as in many bog- and aquatic plants. *Typha latifolia, T. angustifolia, Butomus umbellatus,* foliage leaves.
1b. sword-shaped (ensiformis). With a very thick midrib, hence more or less rhomboid in transverse section. *Iris Pseudacorus,* foliage leaves.
1c. awl-shaped (subulatus). Circular in transverse section; firm and with a sharp apex. Juniperus communis, Ulex europaeus, foliage leaves.
1d. needle-shaped (acerosus). More or less cylindrical and rigid with an acute apex. *Pinus sylvestris, Picea excelsa,* foliage leaves.

S. No. 205. (cf. S. No. 199). The apex of the blade may be:
1a. acute or sharp-pointed (acutus). In lanceolate, tri-

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[1]) A. de Candolle. La Phytographie, Paris 1880, p. 198. Oudemans en de Vries. Leerboek der Plantenkunde, Vol. II, Nijmegen 1895, p. 101.

angular, deltoid, rhomboid, linear, sword-shaped and awl-shaped blades.
1b. blunt (obtusus). In orbicular, obovate, spatulate blades.
1c. taper-pointed (acuminatus). Acute, but the apex extends higher than could be expected from the curvature of the margin in the vicinity of the apex. *Tilia platyphyllos, Ulmus campestris,* foliage leaves; the so-called drip tips of foliage leaves (Stahl).
1d. truncate (truncatus) and emarginate (emarginatus) *Liriodendron tulipifera,* foliage leaves.

S. No. 206. (cf. S. No. 199). The base of the blade may be:
1a. acute (acutus). In lanceolate, rhomboid, obovate, wedge-shaped and obcordate blades.
1b. blunt (obtusus). In egg-shaped, orbicular and oval blades.
1c. truncate (truncatus). In triangular and deltoid blades.
1d. notched. See S. No. 215.

S. No. 207. (cf. S. No. 199). Concerning veins the following subjects will be dealt with:
1a. their several kinds. See S. No. 208.
1b. their mode of arrangement. See S. No. 209.

S. No. 208. (cf. S. No. 207). The following kinds of veins may be distinguished:
1a. the midrib or rib (costa). It extends from the base to the apex of the blade, thus generally dividing it into two mirror images. If the halves are not equal we distinguish:
  2a. the unequal sided blade (inaequalis). *Ulmus campestris, Begonia,* foliage leaves; *Eucalyptus globulus,* sickle-shaped leaves of the later stages of the tree.
1b. the primary veins (nervus lateralis). The great veins at both sides of the midrib.
1c. the veinlets (vena). The smallest veins arising from midrib and primary nerves and occurring in all parts of the blade.

S. No. 209. (cf. S. No. 207). With respect to venation the blade may be distinguished as having:
1a. divergent veins (nervis divergentibus).
  2a. palminerved or palmately veined (palminervis). The primary veins all arise from one point at the base of the midrib. *Acer Pseudo-Platanus,* foliage leaf.
  2b. feather-veined (penninervis). The primary veins arise in various places from the midrib. *Quercus Robur,* foliage leaf.
1b. veins uniting together at the top of the blade (nervis confluentibus).
  2a. straight-veined (rectinervis). All veins straight and more or less parallel. *Gramineae,* foliage leaves.
  2b. curve-veined (curvinervis). Only the midrib straight, primary nerves curved. *Convallaria majalis, Funkia,* foliage leaves.

S. No. 210. (cf. S. No. 199). The margin of the blade may be strongly modified by the occurrence of ramifications and in this respect the following terms are in use:
1a. entire (integer). There is no ramification. *Fagus sylvatica,* foliage leaf.
1b. divided (divisus). The blade shows ramification into laciniae or segments. The divisions may be:
  2a. independent. They do not modify generally the general outline of the blade and often do not exhibit a special relation to midrib or primary veins. See S. No. 211.
  2b. dependent (folium dissectum, dissected blade). They modify generally the general outline of the blade and occur respectively between two primary veins or between a primary vein and the midrib. See S. No. 212.
  2c. of the notched base. See S. No. 215.

S. No. 211. (cf. S. No. 210). With respect to independent divisions the margin may be:
1a. sawed (serratus). Sinus (sinus) and angles (angulus) both acute. *Urtica dioica, Urtica urens, Tilia platyphyllos,* foliage leaves.
  2a. biserrate or duplicato-serrate (biserratus). The teeth are sawed again. *Kerria japonica, Ulmus campestris,* foliage leaves.
1b. repandus (repandus). Sinus and angles both obtuse. *Sisymbrium Alliaria,* foliage leaf.
1c. toothed (dentatus). Sinus obtuse, angles acute. *Castanea sativa (C. vesca), Ilex Aquifolium,* foliage leaves.
1d. crenate (crenatus). Sinus acute, angles obtuse. *Althaea rosea, Caltha palustris,* foliage leaves.

S. No. 212. (cf. S. No. 210). Concerning dependent divisions the following subjects will be dealt with:
1a. their several kinds. See S. No. 213.
1b. their combination with nervature. See S. No. 214.

S. No. 213. (cf. S. No. 212). With respect to the depth of dependent divisions the blade may be:
1a. lobed (lobatus). The divisions do not extend to the middle of the primary veins.
1b. split (fissus). The divisions extend to the middle of the primary veins.
1c. parted (partitus). The divisions extend beyond the middle of the primary veins.

S. No. 214. (cf. S. No. 212). With respect to dependent divisions in combination with nervature (cf. S. No. 209) the blade may be:
1a. palmatilobate (palmatilobatus). Palminerved and lobate. *Hedera Helix,* foliage leaf.

1b. palmatifid (palmatifidus). Palminerved and split. *Acer Pseudo-Platanus,* foliage leaf.
1c. palmatisect (palmatipartitus). Palminerved and parted. *Ranunculus acris,* foliage leaf.
1d. pinnatilobate (pinnatilobatus). Feather-veined and lobate. *Quercus Robur,* foliage leaf.
1e. pinnatifid (pinnatifidus). Feather-veined and split. *Quercus rubra,* foliage leaf.
1f. pinnatisect (pinnatipartitus). Feather-veined and parted. Many foliage leaves of *Taraxacum officinale.*

S. No. 215. (cf. S. No. 210). With respect to the character of apex and basal lobes or laciniae the blade with a notched base may be:
1a. heart-shaped or cordate (cordatus). Apex acute, laciniae at the base blunt. *Aristolochia Sipho, Petasites officinalis,* foliage leaves.
1b. kidney-shaped (reniformis). Apex and laciniae at the base blunt. *Nepeta Glechoma (Glechoma hederacea), Nuphar luteum,* foliage leaves.
1c. arrow-headed (sagittatus). Apex and laciniae at the base acute. *Sagittaria sagittifolia,* foliage leaf.
1d. halbert-headed (hastatus). Arrow-headed, but the laciniae at the base extend horizontally. *Rumex Acetosella,* foliage leaf.
  2a. eared (auriculatus). Halbert-shaped with a large apical part and small laciniae at the base, which are called ears (auricula). *Salvia officinalis, Solanum Dulcamara,* foliage leaves.

S. No. 216. (cf. S. No. 196). The blade of a compound phyllome may exhibit the following parts:
1a. the rhachis (rhachis). This is the petiole-like part of the blade forming the continuation of the petiole; it is often ramified, in highly compound leaves even repeatedly. It may be segmented into:
  2a. a rhachis of the first order.
  2b. rhaches of the second, third, etc. orders.
  2c. petiolules. They are the last ramifications of the rhachis, each bearing a single blade.
1b. the leaflets (foliolum). They are the parts resembling simple blades and must be described like these. See moreover M. N. No. 15.

S. No. 217. Compound phyllomes may be:
1a. palmate (palmatus). The leaflets arise at the top of the petiolus or of the rhaches. In most cases there is a terminal leaflet, so that the number of blades is odd; in some cases even numbers occur. See S. No. 218.
1b. pinnate (pinnatus). The leaflets arise along the rhachis or its ramifications. Here also the number of leaflets is mostly odd. If the leaflets are placed in pairs at the same level the

term pairs of leaflets or juga (jugum) is used. See S. No. 219.

S. No. 218. (cf. S. No. 217). The palmate phyllome with respect to the number of blades may be:
1a. bifoliolate (bifoliolatus). *Vicia Faba,* foliage leaf.
1b. trifoliolate or ternate (trifoliolatus). *Menyanthes trifoliata, Trifolium pratense,* foliage leaves.
1c. quadrifoliolate (quadrifoliatus). *Marsilia salvatrix,* foliage leaf.
1d. quinquefoliolate or quinate (quinquefoliolatus). *Vitis (Ampelopsis) hederacea, Aesculus glabra (rubicunda), Potentilla reptans,* foliage leaves.
1e. septemfoliolate (septemfoliolatus). *Aesculus Hippocastanum,* foliage leaf.
1f. novemfoliolate (novemfoliolatus). *Cannabis sativa, Lupinus luteus,* foliage leaves.
1g. multifoliolate. More than nine leaflets. *Lupinus polyphyllus,* foliage leaf.
1h. biternate (biternatus). Ternate, but each leaflet is ternate again. *Aegopodium Podagraria, Aquilegia vulgaris,* foliage leaves.

S. No. 219. (cf. S. No. 217). The pinnate phyllome may be:
1a. unifoliolate (unifoliolatus). Only the terminal leaflet is developed. Its rhachis is represented by an articulation or joint (articulatio). *Berberis vulgaris, Citrus Aurantium,* foliage leaves.
1b. imparipinnate or pinnate with an odd terminal leaflet (imparipinnatus). *Robinia Pseudacacia, Rosa, Sorbus Aucuparia,* foliage leaves.
1c. paripinnate or equally pinnate (abrupte pinnatus). Terminal leaflet wanting. *Pisum sativum,* foliage leaf.
1d. interruptedly pinnate (interrupte pinnatus). Each time between the successive great leaflets several small leaflets. *Solanum tuberosum, Potentilla anserina, Spiraea Ulmaria,* foliage leaves.
1e. bipinnate (bipinnatus). Pinnate, but each leaflet is pinnate again. *Levisticum officinale, Polystichum Filix mas,* foliage leaves.
1f. tripinnate (tripinnatus). Bipinnate, but each leaflet is pinnate again. *Conium maculatum, Anthriscus sylvestris,* foliage leaves.

S. No. 220. Digitato-pinnate (digitatopinnatus). Palmate with pinnate parts instead of leaflets. *Mimosa pudica,* foliage leaf.

S. No. 221. (cf. S. No. 196). The following stipular parts of phyllomes may be distinguished.
1a. stipules (stipula). Two generally small leaflets, arising from the leaf-base or from the caulome on both sides of the phyllome. They may coalesce with the petiole or with each other, which gives rise to the following cases:

2a. free stipules (stipulae liberae). *Viola tricolor, Lathyrus Aphaca,* foliage leaves.

Since the life-time of stipules is by no means always the same as that of the phyllome to which they belong, it is necessary to direct the reader's attention towards this character here, and therefore we may distinguish in this respect:

3a. caducous stipules. They are lost very soon after the opening of the bud. *Ulmus campestris, Fagus sylvatica,* foliage leaves.

3b. deciduous stipules. They remain during the whole or a larger part of the life-time of a deciduous phyllome to which they belong. *Viola tricolor, Liriodendron tulipifera,* foliage leaves.

3c. persistent stipules. They remain during a longer period than the life-time of the corresponding phyllome, often even many years, *Robinia Pseudacacia.*

2b. adnate stipules (stipulae adnatae). The stipules are in longitudinal organic connection with the petiole of the leaf to which they belong. *Rosa, Trifolium pratense,* foliage leaves.

2c. interpetiolar stipules (stipula interpetiolaris). The adjoining stipules of two different phyllomes fuse together, forming an apparent simple stipule between the two phyllomes. *Humulus Lupulus, Galium Cruciata,* foliage leaves.

2d. axillary stipules (stipula axillaris). The stipules belonging to one phyllome fuse between the caulome and the petiole. *Victoria regia,* foliage leaves, *Aira flexuosa,* palea inferior.

2e. antidromous stipules (stipula antidroma). The stipules belonging to one phyllome fuse at the opposite side of the caulome. *Alchemilla vulgaris, Ricinus communis,* foliage leaves.

1b. ochrea (ocrea). It is tubular and sheath-like, surrounding the caulome and in the young condition usually overarching the younger phyllomes. It represents two lateral stipules, which are fused not only between caulome and petiole, but also at the opposite side of the caulome. *Rheum Rhaponticum, Rumex, Polygonum, Platanus occidentalis, Ficus elastica,* foliage leaves.

1c. the ligule (ligula). It is a small thin membrane arising at the dorsal side of the phyllome, either in the vicinity of the base *(Selaginella, Isoetes)* or at the place of union of sheath and blade *(Gramineae,* foliage leaves), or at the place of union of claw and limb *(Lychnis flos cuculi,* petal).

1d. stipellas (stipella). Parts resembling stipules, but placed at the base of petiolules or leaflets in compound leaves. Rather rare. *Robinia Pseudacacia, Thalictrum,* foliage leaves.

S. No. 222. With respect to the presence or absence of stipules we may distinguish:

1a. stipulate phyllomes. They have stipules. *Pisum savitum,* foliage leaves.

1b. exstipulate phyllomes. Stipules are wanting. *Gentiana lutea, Ranunculus repens,* foliage leaves.

2. Special kinds of phyllomes and specially differentiated parts of phyllomes.

S. No. 223. Concerning special kinds of phyllomes and parts of them the following subjects will be dealt with:

1a. foliage leaves. See S. No. 224.
1b. petaloid phyllomes. See S. No. 225.
1c. scale leaves or leaf-scales. See S. No. 226.
1d. twining phyllomes. See S. No. 227.
1e. spines representing phyllomes. See S. No. 228.
1f. tendrils representing phyllomes. See S. No. 229.
1g. pitchers. See S. No. 230.
1h. utricles. See S. No. 231.
1i. phyllomes metamorphosed into organs of storage for reserve materials. See S. No. 238.
1k. phyllomes metamorphosed into organs of suction. See S. No. 239.
1l. phyllomes being fructifications or belonging to them.
  2a. sporophylls. See S. No. 232.
  2b. perichaetial phyllomes. See S. No. 235.
  2c. phyllomes of the perianth or floral envelopes. See S. No. 236.
  2d. nectaries representing phyllomes. See S. No. 237.

S. No. 224. (cf. S. No. 223). Foliage leaves, generally referred to simply as leaves. (cf. S. No. 75.) This term designates phyllomes which have the function of carbon assimilation; their blades mostly exhibit a large surface and are always coloured by pigments contained in plastids (see S. No. 489), whilst in the land-flora and among plants growing in fresh water the green colour predominates.

S. No. 225. (cf. S. No. 223). Petaloid phyllomes. They exhibit a tender texture and are either white or coloured, but not green. *Pelargonium zonale,* petals; *Caltha palustris,* calyx; *Rheum nobile* (Hook), bracts; *Richardia aethiopica,* spathe.

S. No. 226. (cf. S. No. 223). Scale leaves or leaf-scales. They are relatively small, broad and have a slight length; they have a very simple outline even in plants which show highly compound foliage leaves; they generally correspond to the basal parts of phyllomes; they have no prominent veins; they are mostly coloured yellowish, brown or reddish, sometimes they are colourless and not often green, although the foliage leaves of the same plant may be so; their texture may be membranous, leathery, fleshy or even succulent. *Pinus,* primary stem and strong lateral shoots in stead of foliage leaves; *Monotropa, Neottia, Corallorhiza, Orobanche,* aerial shoots in stead of foliage leaves; *Cycas,* zones of scale leaves alternating on the stem with zones of large foliage leaves; *Polygonatum multiflorum, Corallorhiza innata,* rhizomes representing cormi; *Quercus,* seedlings and *Aegopodium, Orchis, Polygonatum,* lateral shoots of underground axes, cataphylls (see S. No. 244); *Abies pectinata,* bract scale and ovuliferous scale of cones (see S. No. 299 and 399); *Humulus Lupulus,* bracts (see S. No. 399).

Moreover the following special kinds may be distinguished:
1a. bud scales. See S. No. 284.
1b. bulb scales. See S. No. 288.
1c. tuber scales. See S. No. 294.

S. No. 227. (cf. S. No. 223). Twining phyllomes. The rhachis of a compound phyllome behaves like a twining caulome (cf. S. No. 177), while the leaflets represent its foliage leaves. *Lygodium.*

S. No. 228. (cf. S. No. 223). Spines representing phyllomes leaf-spines or leaf-thorns. (cf. S. No. 75). They may appear simply as reduced phyllomes (several desert plants), sometimes they may bear shoots in their axil *(Berberis vulgaris)* or they may represent stipules *(Robinia Pseud-acacia; Acacia sphaerocephala,* large stipular ant-thorns).

S. No. 229. (cf. S. No. 223). Tendrils representing phyllomes or parts of them; leaf-tendrils. (cf. S. No. 75). *Sicyos angulata; Pisum sativum* and *Lathyrus Aphaca* (leaflets).

S. No. 230. (cf. S. No. 223). Pitchers. (cf. S. No. 75). They are the tubular or cup-shaped terminal portions of the blades of the phyllomes and occur in some insectivorous plants. *Nepenthes; Sarracenia; Cephalotus; Darlingtonia.*

S. No. 231. (cf. S. No. 223). Utricles¹). (cf. S. No. 75). They are small green bladders being the metamorphosed segments of leaves in certain insectivorous plants. *Utricularia.*

S. No. 232. (cf. S. No. 223). Concerning sporophylls the following subjects will be dealt with:
1a. sporophylls in general. See S. No. 233.
1b. sporocarps. See S. No. 234.

S. No. 233. (cf. S. No. 232). Sporophylls. This is a general term for phyllomes which produce haploid spores. They are all fructifications, although in some cases certain parts of them, not producing spores, may retain the colour and structure of foliage leaves, like in some Filices (cf. S. No. 78). When they are completely metamorphosed into fructifications, they may take part in the formation of more extended and complicated fructifications, as in flowers (higher plants, stamens and carpids).

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¹) Utricles were generally considered by the older botanists as parts of phyllomes, but more recent investigations tend to show that their nature is uncertain.

Fovea is a term for designating an elongated pit, which appears on the dorsal side of some sporophylls and contains a sporangium *(Isoetes)*.

With respect to the kind of spores produced by them we may distinguish:
1a. isosporophylls. They appear in isosporous *Pteridophyta* and from their spores may arise monoecious *(Pteris aquilina, Lycopodium clavatum)* or dioecious *(Equisetum)* prothallia.
1b. microsporophylls. They produce microsporangia. Heterosporous *Pteridophyta; Gymno-* and *Angiospermae,* stamens.
1c. megasporophylls or macrosporophylls. They produce megasporangia. Heterosporous *Pteridophyta; Cycas; Angiospermae,* carpids.

S. No. 234. (cf. S. No. 232). Sporocarps (sporocarpium). This term designates the fertile segment of a sporophyll, if it forms a plurilocular capsule, containing a sorus in each loculus. *Pilularia, Marsilia.*

S. No. 235. (cf. S. No. 223). Perichaetial phyllomes. They are the enveloping phyllomes of the receptacles of Musci. See S. No. 298.

S. No. 236. (cf. S. No. 223). Phyllomes of the perianth or floral envelopes. See S. No. 319.

S. No. 237. (cf. S. No. 223). Nectaries representing phyllomes. *Eranthis hiemalis* and *Aconitum Napellus,* flowers.

S. No. 238. (cf. S. No. 223). Phyllomes metamorphosed into organs of storage for reserve materials. *Allium Cepa* and *Hyacynthus orientalus,* bulb-scales. For cotyledons See S. No. 244 and S. No. 421.

S. No. 239. (cf. S. No. 223). Phyllomes metamorphosed into organs of suction. *Phoenix dactylifera* and *Trapa natans,* cotyledons. See moreover S. No. 244 and S. No. 421.

C. Cormus. Confer for the meaning of this term S. No. 73.

1. General description.

S. No. 240. In the general description of cormi the following subjects will be dealt with:
1a. differentiation of the cormus. See S. No. 241.
1b. spatial relations between caulomes, phyllomes and cormus-individuals. See S. No. 253.

S. No. 241. (cf. S. No. 240). Differentiation of the cormus. In the higher plants the cormus is often specialized by the appearance of various kinds of differentiation which exhibit a certain independence of one another, but nevertheless are intermixed in various ways. The terms for designating the several kinds of differentiation are the following:

1a. cormus-individual, cormoid system. See S. No. 242.
1b. regions of the cormus characterised by certain peculiarities of their caulome and phyllomes and moreover by their position and reciprocal arrangement. See S. No. 243.
1c. periodic shoot. See S. No. 249.
1d. annual shoot. See S. No. 250.
1e. succession of cormi. See S. No. 251.
1f. succession of cormi formula. See S. No. 252.

S. No. 242. (cf. S. No. 241). Cormus-individual. This term indicates a kind of subordinate or organ-individual, into which the cormus of most plants is divided; they appear generally in a considerable, often in an enormous number, although indeed in relatively few cases the whole cormus may consist of only a single one.

Their individuality is chiefly manifested by the fact that they are in their completeness the sole products of one and the same vegetative cone. They begin with the formation of the vegetative cone and end when the longitudinal growth of this cone is finished, although considerable growth in a transverse direction may afterwards still take place. Thus the trunks of *Palms* and *Tree-ferns* are constituted by a single cormus-individual. The main stem and all branches older than one year of a certain number of trees must also be considered as representing each a single cormus-individual, notwithstanding its growth in length may be suspended during winter or dry seasons. The occurrence of this case is relatively rare, because the greater number of our trees produces sympodia (cf. S. No. 59); *Pinus, Acer, Aesculus,* often also *Quercus* and *Fagus sylvatica* may serve as examples. On the other hand the lateral flowers of the higher plants including their pedicels correspond to cormus-individuals exhibiting a narrowly limited longitudinal growth and a short life-time. If in consequence of the formation of a new lateral vegetative cone a branch is formed, this is the beginning of a new cormus-individual, which in its turn may produce others again and again.

They cannot be divided into two halves which again represent complete cormus-individuals.

Their individuality is further manifested by the appearance of several regions with variously differentiated phyllomes in a well defined order and moreover by certain spatial relations between caulomes, phyllomes and cormi reciprocally; both these subjects will be dealt with below.

New cormus-individuals formed by branching often are of the same kind as the individual which produced them and this process may repeatedly take place, as in trees, so that the size of the plant is greatly increased; these secondary cormus-individuals have been called by Alexander Braun non-essential members in the order of sequence of cormus-individuals. On the other hand when a branch appears it often exhibits metamorphosis, so that another kind of cormus-individual arises which performs other functions necessary for the life of the plant; in the order of sequence these have been called essential members, for instance the formation of flowers as branches of leafy boughs or of inflorescences, the formation of dwarf branches from elongated branches in *Pinus*. The appearance of an essential member may be followed again by the formation of non-essential members, as in dichasial inflorescences.

The term cormoid system is useful for designating any branched cormus consisting of two or more cormus-individuals, whether essential or non-essential.

When two or more kinds of essential members appear, the order of sequence of the cormus-individuals is called a simple alternation of generations (cf. S. No. 25). See moreover M. N. No. 16.

S. No. 243. (cf. S. No. 241). Regions of the cormus characterised by certain peculiarities of their caulome and phyllomes and moreover by their position and reciprocal arrangement [1]). The cormus-individuals and cormoid systems have a tendency to be divided into a certain number of regions placed longitudinally one above the other and chiefly characterised by different specializations of caulome and of phyllomes, which generally perform special functions. We may distinguish:

1a. the vegetative region (cf. S. No. 75).
  2a. the cataphyllary region. See S. No. 244.
  2b. the middle region. See S. No. 245.
1b. the region of fructification (cf. S. No. 78).
  2a. the bracteal or hypsophyllary region. See S. No. 246.
  2b. the region of phyllomes enveloping gemmae, gametangia or sporophylls. See S. No. 247.
  2c. region of gemmae, gametangia or sporophylls. See S. No. 248.

S. No. 244. (cf. S. No. 243). The cataphyllary region; the region of cataphylls or cataphyllary phyllomes (cataphyllum, squama). The phyllomes of this region essentially appear as scale leaves, although transitional forms towards foliage leaves and even fully developed foliage leaves may occur, petaloid metamorphoses also appear now and then when the cataphylls are placed in the region of fructifications (bracteal region see S. No. 246); moreover they may appear in some cases as organs of storage or of suction.

This region may be wanting in the cormi of lower plants *(Aspidium Filix mas)*, but in *Gymno-* and *Angiospermae* it is of almost universal occurrence, while in *Musci* it is by no means rare.

In cormus-individuals it is mostly to be found as the basal region, sometimes remaining strictly limited to the base, but in other cases a more considerable basal part of the cormus-individual may bear scale leaves, which further towards the apex are replaced by foliage leaves *(Aegopodium podagraria, Polygonatum officinale,* aerial branches of rhizomes; *Struthiopteris germanica,* subterranean stolons afterwards growing out into aerial leafy branches; *Quercus Robur,* seedlings; *Hyacinthus orientalis,* bulbs); in other cases again it extends over the whole cormus-individual, as in *Orobanche* and *Monotropa,* where no foliage leaves are developed and the cataphyllary region extends even up the bracteal region, or as in many rhizomes. In periodic shoots, see S. No. 249, into which some cormus-individuals are divided, it also appears. Examples are afforded by *Pinus* and *Acer* in their bud-scales; by *Cycas revoluta* in zones of scale leaves alternating with zones of foliage leaves and in the female plant with zones of megasporophylls; by *Osmunda regalis* [1]) in bud-scales covering the apical buds of the rhizomes.

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[1]) Kerner von Marilaun. Das Pflanzenleben, 2. Aufl. Band I, Leipzig 1896, p. 570—625. Gestalt der Blattgebilde.

These facts lead to the following modes of disposition of the cataphyllary region: 1. there is only a single one, if the whole cormus consists of a single individual *(Papaver somniferum,* poorly developed plants); 2. it appears repeatedly, either on the periodic shoots (see S. No. 249) of a single cormus-individual or throughout the whole cormoid system in non-essential as well as in essential cormus-individuals, thus in the latter case even taking part in the formation of the bracteal region (inflorescences and flowers); 3. it extends uninterruptedly over two or more cormus-individuals belonging to the same cormoid system *(Polygonatum officinale,* rhizome).

The following special kinds of cataphylls may be distinguished:

1a. prophylls. They are a more or less specially differentiated kind of basal phyllomes appearing in the great majority of cormus-individuals. They are sometimes but slightly different from higher cataphylls or even foliage leaves, but yet it is mostly possible to recognize them and to determine their number and places. They may be wanting in some cases; a single one is characteristic of *Monocotyledons* and is mostly placed on the adaxial side of the caulome which bears it; the number of two is characteristic for the *Dicotyledons* and they are mostly placed transversely right and left.

2a. cotyledons. They are the prophylls of the primary cormus-individuals arising from the embryo and here again a single one is characteristic of *Monocotyledons* and two of *Dicotyledons* and *Gymnosperms.* See moreover S. No. 411, 421 and 422.

2b. bracteoles (bracteola). This term designates the prophylls of the cormus-individuals which are developed into flowers without producing a middle region; *Monocotyledons* exhibiting mostly one, *Dicotyledons* mostly two. They belong also to the bracteal region to be mentioned below and may be at the same time subtending phyllomes (see S. No. 306) of lateral flowers. Phyllomes corresponding to bracteoles in position and arrangement may be metamorphosed into foliage leaves and in a few instances they may even be transformed into sepals; both cases may be observed in *Meconopsis cambrica* [1]. Bracteoles showing a petaloid character are found in *Neuropeltis* and *Prevostea* [2].

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[1]) Rabenhorst III, Luerssen, Leipzig 1889, p. 524.

S. No. 245. (cf. S. No. 243). The middle region. The phyllomes of this region essentially appear as foliage leaves, although in some cases they may be metamorphosed into scale leaves, for instance on the elongated branches of *Pinus*, where the foliage leaves are produced by dwarf-shoots which develop in the axils of those scale leaves, or into spines, for instance on the elongated branches of *Berberis vulgaris*, where the foliage leaves are produced by dwarf-shoots in the axils of those spines; further examples of scale leaves are provided by *Thuia, Lycopodium* and *Selaginella*. Moreover several special metamorphoses may appear for instance twining phyllomes (cf. S. No. 227), spines (S. No. 228), tendrils (S. No. 229), pitchers (S. No. 230), utricles (S. No. 231). This region is wanting in the reproductive part of the plant, but very seldom in the vegetative part, for instance in *Balanophora* and *Rafflesia;* in most vegetative aerial cormi of lower and higher plants it is strongly developed; in cormus-individuals with a cataphyllary region it is the next region towards the apex and in many cases it extends over a considerable length, for instance in *Tree-Ferns* and *Palms*, where almost the whole trunk is formed by the middle region of a single cormus-individual; it moreover appears in periodic shoots (see S. No. 249) into which some cormus-individuals are divided *(Pinus, Acer)*. These facts lead to the following modes of arrangement of the middle region; 1. there is only a single one, if the whole vegetative cormus consists of a single individual only *(Palmae; Papaver somniferum,* poorly developed plants); 2. it appears repeatedly, either on the periodic shoots (see S. No. 249), into which a single cormus-individual is divided, or in a cormoid system in every cormus-individual belonging to the vegetative region, but it never takes part in the formation of the reproductive region.

1a. radical leaves. This term designates foliage leaves appearing in the nearest vicinity of the root on a caulome with excessively short internodes. They are the principal foliage leaves of the plant. *Beta vulgaris* in the first year; *Bellis perennis; Taraxacum officinale, Agave.*

S. No. 246. (cf. S. No. 243). The bracteal or hypso-

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[1] For the knowledge concerning transformation into sepals I am indepted to a verbal communication of my colleague Dr. J. C. Schoute. The lateral flowering branches on the aerial parts of this plant, each bearing a single flower, possess two prophylls in the shape of small foliage leaves. These however are wanting in the highest flowering branches and have been transformed into sepals of the flower as is shown by their lateral position.

[2] Velenovsky, Vergleichende Morphologie der Pflanzen III. Prag. 1910, p. 933.

phyllary[1]) region. This region is the least important, the most straggling and often the most incomplete of all the regions into which the cormus may be segmented. It is absent in the cormi of *Bryophyta* and *Pteridophyta*, whilst in the higher plants its occurrence is limited to the region of fructifications or even to inflorescences.

The phyllomes of this region are never foliage leaves, because these are characteristic of the vegetative region and always belong to it. They mostly appear as scale leaves, often green, sometimes brown or even colourless and membranous (floral bracts of *Compositae)*. In a rather considerable number of cases they are metamorphosed into large petaloid phyllomes *(Rheum nobile, Dalechampia, Poinsettia, Bougainvillea, Calla palustris* and many other *Aroideae)*.

Concerning its occurrence in the higher plants it may be said, that it is wanting in complete cormus-individuals which exhibit both a well-developed vegetative and reproductive region, if the latter consists of a single flower only, as in *Papaver somniferum,* where the middle region is followed by a stalk bearing at its top only the flower, but no bracts of any kind appear. *Papaver somniferum* produces only non-essential lateral cormus-individuals of several orders, which have a tendency to become more feeble and incomplete with the increase of their order. This process ends in the production of a flower only and obviously the bracteal region, wanting in the stronger does not appear in the feebler cormus-individuals. *Paris quadrifolia* in its aerial parts affords an example of the same kind, exhibiting four foliage leaves and a single flower, but no bracteal region.

The bracteal region on the other hand always appears in plants which possess flowers composed of separate cormus-individuals, lacking a middle region and foliage leaves.

The position of this region is different in various cases and there is more or less a contrast between botryose (racemose) and cymose inflorescences. In the former case if there is an apical inflorescence, the foliage leaves appearing in the middle region of the cormus-individual which bears the inflorescence may gradually *(Digitalis purpurea)* or at once *(Lupinus luteus)* be metamorphosed into bracts of the inflorescence; in other cases racemose inflorescences are lateral, arising in the axils of foliage leaves and then bracts may appear along the whole length of the peduncle, as in *Veronica Chamaedrys* and *Prunus avium.* If the peduncle is strongly branched, as in many *Gramineae,* the bracteal region is of course strongly extended. In cymose inflorescences on the other hand the bracteal region is exclusively composed of bracteoles, which are cataphylls belonging to successive cormus-individuals each ending in a flower and arising from the axils of bracteoles belonging to lower branches, as in *Fragaria vesca* and *Cerastium;* in these cases the bracteal region is, strictly speaking, not an autonomous region at all.

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[1]) This term corresponds to the german term „Hochblätter" which is not a very happy one, because the phyllomes belonging to them are also the cataphylls of the region of fructification. The term bracteal region is therefore the better one.

With respect to spatial relations bracteal phyllomes may often appear as subtending phyllomes of branches of the inflorescence or of single flowers *(Daucus Carota; Fragaria vesca;* floral bracts of *Compositae)*. But they often do not develop branches in their axils, like the spathe of *Richardia aethiopica* and other *Aroideae,* the bracts on the scape of *Curcuma longa* and many bracteoles.

Some bracteal phyllomes more or less envelop either a single flower or an inflorescence and here we may distinguish: 1. a spathe (see S. No. 306). 2. an involucre (see S. No. 306).

The frequently occurring incompleteness of the bracteal region may be illustrated by the following examples. In *Papaver somniferum* and *Tulipa sylvestris* no bracteal region occurs; terminal flowers occurring now and then, sometimes rather abundantly *(Prunus laurocerasus)* in racemose inflorescences are devoid of bracts, nor do terminal peloriae, as in *Digitalis purpurea,* possess them; all *Aroideae* possess a spathe, but bracts and bracteoles are totally wanting; in the order of *Cruciferae* bracts and bracteoles are habitually wanting; in *Helianthus annuus* and many other *Compositae* an involucre is developed, but floral bracts are wanting; bracteoles never appear in the orders of *Compositae* and *Umbelliferae,* nor in *Primulaceae,* where the two bracteoles are metamorphosed into the first two sepals.

Bracteal phyllomes may be deciduous *(Lupinus densiflorus)* or caducous *(Lupinus polyphyllus)*.

S. No. 247. (cf. S. No. 243). The region of phyllomes enveloping gemmae, gametangia or sporophylls. The phyllomes of this region appear as a perichaetum (see S. No. 298) or as a perianth (see S. No. 319) and are placed above the bracteal region, where such occurs.

S. No. 248. (cf. S. No. 243). The region of gemmae, gametangia or sporophylls. This is the apical zone of the region of fructifications. This region itself is in the majority of cases the apical one of cormus-individuals and cormoid systems. Nevertheless it may sometimes be succeeded again by other regions. Examples of this kind have been mentioned in S. No. 249.

S. No. 249. (cf. S. No. 241). Periodic shoot[1]). This term designates parts periodically formed during the progressive development of one and the same cormus-individual and characterised by a complicated rhythm in the usual regular sequence of its regions, which has been dealt with in the preceding article. The periods mentioned above may be of very different lengths; sometimes they correspond to a single summer or rainy season of the year, so that they may be called annual shoots (see S. No. 250); in other cases they may extend over more than one year; in other cases again several periodic shoots are formed during a single vegetative period. The rhythm in the sequence of the regions is often, but not always manifested by a kind of resumption in the sequence of the regions, so that for instance a cataphyllary and middle region are followed at regular intervals after a time of rest by shoots, composed of the same two regions. The following examples may illustrate the particulars mentioned above: *Pinus, Acer* and *Juglans regia,* the yearly increment of main stem and branches formed in spring as annual shoots; *Polytrichum commune,* increment of male plants; *Cycas circinalis,* the increment in length formed within a space of one or two years, each periodic shoot commencing with a cataphyllary region, followed in the male plant by a middle region consisting of foliage leaves and in the female plant either by a region of foliage leaves or by a region of megasporophylls; the increments in the preceding three cases fairly resembling ordinary cormus-individuals; *Ananassa sativa,* a lower region of foliage leaves and a region of fructification, together forming a periodic shoot, are again followed in the same vegetative period by a region of foliage leaves, which may afterwards grow out into a new plant; *Callistemon Metrosideros* and *Malaleuca* afford instances of the same kind in which an inflorescence is followed by a new shoot [1]); *Beta vulgaris,* radical rosette of the first and increment of the second year; *Daucus carota,* radical rosette of the first year and foliage cormus of the second year with scape and involucre; *Lycopodium Selago,* alternating formation of foliage leaves and region of sporophylls within a single summer.

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[1]) The term shoot (in German Sprosz, Trieb; Dutch loot) is often used in Botany, but has a somewhat vague meaning. It sometimes designates a young growing branch or twig, others refer to it as being a stem and its leaves collectively (Strasburger, A textbook of Botany, London 1908, third Eng. ed. p. 18; sixteenth German ed. 1923, p. 62 and 73). Marshall Ward (Marshall Ward, Trees, vol. I, Cambridge 1904) applies the term "shoot-system" to the parts aboveground no matter how complex they may become (p. 3) and uses the term "shoot

S. No. 250. (cf. S. No. 241). Annual shoots. This term, although certainly one of secondary importance, is often used in phytography, for designating in a general way the increment in length of a cormus within the space of a single year. Obviously for

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in a narrower sense" for the product of a bud during the season in which it is developed (p. 69). Alexander Braun (Braun, Das Individuum der Pflanze, Abh. d. K. Akad. Berlin, 1853), claims for lateral and adventitious roots the same character of individuality which he has proved to belong to lateral shoots of all kinds. It is no doubt possible to apply the term in such a way that no confusion can arise, but it will not be used in this Synopsis, and the terms cormus and cormus-individual, which cannot be misunderstood, will replace it; I think that it should be avoided in pen-portraits. Nevertheless the terms periodic shoot and annual shoot have both been introduced into the text of the synopsis and to both combinations of the term shoot a well defined unequivocal meaning has been secured.

[1]) Kerner. Das Pflanzenleben, second ed. Bd. I, Leipzig 1896, p. 712.

distinguishing such an increment it is necessary that it should exhibit a well defined beginning and end, such as for instance is the case with the well-known Lammas-shoots of *Quercus*. But moreover within the growing period of such an annual shoot there may be an interruption of that growth, like our trees show in the formation of their winterbuds. The development of those buds is commenced in autumn, they remain dormant during winter, so that their development is interrupted till their chief longitudinal growth takes place in the following spring. The extension of annual shoots within the cormus is not always the same and in this respect we may distinguish:

1a. annual shoots corresponding to periodic shoots only. *Pinus, Acer* and *Juglans regia,* yearly increment of stem and branches; *Beta vulgaris* and *Daucus carota,* annual shoots of the first and the second year.

1b. annual shoots corresponding to single complete cormus-individuals. *Tilia* and *Ulmus,* yearly increment of stems and branches; *Quercus, Fagus* and other trees, the lateral so-called Lammas shoots (the apical Lammas shoots forming only a part of the annual shoot).

1c. annual shoots corresponding to cormoid-systems which are often complicated. *Aesculus Hippocastanum,* the product of its mixed winter-buds; *Triticum repens* and all other *Gramineae* with rhizomes, the aerial parts yearly appearing. The whole body of all annual plants could be cited as example of an annual shoot, but it is obvious that in this case the use of such a term would be superfluous and even ill-judged.

S. No. 251. (cf. S. No. 241) Succession of cormi (German: "Sprossfolge" or "Sprossverkettung"). This term designates what Al. Braun[1]) termed alternation of generation and partition of generation of cormus-individuals, and here we may distinguish:

1a. uniaxial or haplocaulescent cormoid systems, plants or species. There is but one kind of essential cormus-individuals in any system or plant, and the primary main axis is capable of producing organs of asexual or sexual reproduction at its apex, in the higher plants in the shape of flowers. In a species there may be two or more kinds of essential cormus-individuals, when it shows the phenomenon of heterogeneous individualization (cf. S. No. 10 and 12), the different kinds of cormus-individuals being distributed over separate plants. (Generationstheilung, partition of generation of Al. Braun). Ramification of the primary axis may take place, even repeatedly, but in this way only non-essential cormus-individuals are formed. *Aspidium Filix mas, Salvinia natans, Helleborus foetidus, Papaver somniferum.*

Examples with heterogeneous individualization: *Linum flavum, Lychnis dioica, Viscum album.*

1b. biaxial or diplocaulescent cormoid systems, plants or species. Any fully developed plant shows two kinds of essential cormus-individuals, one borne by the other, and only the second is capable of asexual or sexual reproduction. *Equisetum limosum* (1 rhizome, 2 aerial green stems often ending in strobili), *Paris quadrifolia* (1 rhizome, 2 aerial branches with foliage leaves and terminal flower), *Viola tricolor* (1 leafy stem, 2 flowers), *Orobanche* (1 stem with cataphylls and bracts, 2 flowers), *Euphorbia palustris* (1 stem with leaves, bracts and involucre, ending in a female flower, 2 male flower).

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[1]) Al. Braun, Das Individuum, Berlin 1853.

Examples with heterogeneous individualization of both kinds of essential cormus-individuals: *Lythrum Salicaria* (1 stem with leaves and bracts, 2 long-styled, mid-styled or short-styled flowers), *Stratiotes aloides* (1 leafy stem, 2 female or male flowers); examples with heterogeneous individualization of the second kind of cormi only: *Pinus silvestris* (1 main stem, 2 dwarf branches, female or male strobili), *Musa sapientum* (1 stem with leaves and bracts, 2 female or male flowers), *Calendula arvensis* (1 stem with leaves and involucrum, 2 three kinds of ray florets and one of disc florets).

N.B. The case of Euphorbia palustris, where the two sexes in one individual plant are placed on cormi of different order, is called subordination by Al. Braun, that of Musa, where they are placed on the same plant in the same order coordination.

1c. triaxial or triplocaulescent cormoid systems, plants or species. Any fully developed plant shows three kinds of essential cormus-individuals, one borne by the other, and only the highest one is capable of asexual or sexual reproduction. *Secale cereale* (1 culm with leaves ending in the axis of the compound spike, 2 spikelets with glumes, 3 flowers), *Plantago major* (1 radical rosette, 2 scape and peduncle with bracts, 3 flowers), *Veronica Chamaedrys* (1 leafy stem, 2 peduncle with bracts, 3 flowers).

Examples of heterogeneous individualization of all three orders of cormi *Myrica Gale* (1 leafy stem, 2 peduncle with bracts, 3 female or male flowers), *Salix Caprea* (1 leafy stem, 2 peduncle with bracts, 3 female or male flowers); with heterogeneous individualization of the second and third order: *Sparganium ramosum* (1 leafy stem, 2 peduncle of female or male inflorescence, 3 female or male flowers), *Quercus Robur* (1 leafy stem, 2 peduncle of female or male inflorescence, 3 female or male flower); with heterogeneous individualization of the third order only: *Climacium dendroides* (1 rhizome with cataphylls, 2 aerial woody stem with cataphylls in the basal and foliage leaves in the upper parts, or with foliage leaves only, 3 female and male receptacles); example with subordination of sexes: *Buxus sempervirens* (1 leafy stem, 2 peduncle with bracts, terminating in a female flower, 3 male flowers).

N.B. In some plants with heterogeneous individualization of plants the different kinds of individuals may have a different scheme of succession of cormi. *Mercurialis annua* female plant biaxial (1 leafy stem, 2 female flowers), male plant triaxial (1 leafy stem, 2 peduncle, 3 male flowers); *Carex dioica* male plant biaxial (1 leafy stem, 2 male flowers), female plant triaxial (1 leafy stem, 2 rudimentary axis with urceolus, 3 female flower); in an analogous way in plants with heterogeneous individualization of at least two orders of cormus-individuals the two sexes may occur in different orders and yet be coordinated: *Juglans regia* (1 stem with cataphylls and leaves, 2 female flower or peduncle of male inflorescence, 3 male flower), *Xanthium spinosum* (1 stem with leaves and bracts, 2 peduncle of female inflorescence with involucre, or male flower; 3 female flower). 1d. quadriaxial, quinquaxial up to pluriaxial, multaxial or tetraplocaulescent, pentaplocaulescent up to pleiocaulescent, polycaulescent cormoid systems, plants or species. Any fully developed plant shows four or more kinds of essential cormus-individuals and only the highest ones are capable of asexual or sexual reproduction. *Trifolium montanum* (1 short thick primary stem, 2 elongated lateral branches, 3 peduncle of inflorescence, 4 flowers).

Example with heterogeneous individualization in all (four) orders: *Phoenix dactylifera* (1 trunk with leaves, 2 rhachis of inflorescence with spathe, 3 secondary rhachis with bracts, 4 female or male flowers); with heterogeneous individualization in the second to fourth order and subordination of sexes: *Ecballium agreste* (1 leafy stem, 2 female flower, 3 peduncle of male inflorescence, 4 male flowers), *Phyllanthus Niruri* (1 erect terete stem with unlimited growth in length and scattered arrangement of cataphylls, 2 spreading terete branches with limited growth and distichous foliage leaves, 3 female flower, 4 male flowers).

S. No. 252. (cf. S. No. 241). Succession of cormi formula. This formula as suggested here for a more general use in Botany was originally divised by Alexander Braun as a short expression for the succession of cormi. It has however been modified in some not very important respects and has been extended by the express mention which is made of the characters of the several cormi taking part in the formation of the cormoid system, while also the place of origin of these cormi is always mentioned. The terms used for characterising the kinds of cormi have not been abbreviated, so that terms like foliage cormus-individuals, rhizomes, elongated and dwarf branches, radical rosettes, buds, bulbs, peduncles, etc. generally occur. Further the several members constituting such a formula are denoted by the following abbreviations:

I, II, III, etc. = first, second, third, etc. kind of essential cormus-individual.

IA, IB.., IIA, IIB.., IIIA, IIIB.. etc. = the different kinds of essential cormus individuals of the first, second, third etc. order in the case of heterogeneous individualization of these orders.

I1, I2, I3... In; II1, II2, II3... IIn = non essential cormus-individuals, the Roman numeral indicating the number in the order of sequence of the essential cormus individuals, the Arabic numeral the same for non-essential cormus-individuals.

PS1, PS2, PS3, etc. = periodic shoot representing successive parts of one and the same cormus-individual.

Cot. = cotyledon.

Ca = cataphyll.

F = foliage leaf.

FS = foliage leaves or other phyllomes belonging to the middle region differentiated into sporophylls.

B = bracts.

b = bracteoles.

SP = spathe.

Inv = involucre.

inv = involucellum.

R = apical regions of fructification (enveloping phyllomes and region of gemmae, gametangia and sporophylls). Of R three modifications may occur viz. 1. R-cormoid receptacle, ♂♀, ♂, ♀ or neutral; 2. R-strobilus, ♂♀, ♂, ♀ or neutral; 3. R-flower, ♂♀, ♂, ♀ or neutral. The following examples of the formulae may be cited [1]), in some of them the formation of non-essential cormus-individuals has been mentioned, in other cases the formula has been limited to the formation of essential cormus-individuals only.

Aspidium Filix mas I, rhizome representing a caulome: F, FS; I1, I2, etc. or Ps1, PS2, etc, rhizomes: F, FS.

Salvinia natans I, foliage cormus-individual: F and FS; I 1, I 2, etc., foliage cormus-individuals: F and FS.

Papaver somniferum I, complete cormus-individual: Cot, F, R-flower, ♂♀; I 1, I 2, I 3, etc., (from I, I 1, I 2, etc.), complete or somewhat incomplete cormus-individuals: Ca, F, R-flower ♂♀; F, R-flower ♂♀, or R-flower ♂♀.

Helleborus niger I, foliage cormus: Cot, F; PS1, PS2, etc, foliage cormi: Ca, F . . .; PSn, flowering cormus: Ca, b, R-flower [2]) ♂♀; I 1, I 2, etc., (from I, I 1, etc, like I, PS1 till PSn).

Mnium hornum IA complete cormus individual: Ca, F, R-cormoid receptacle ♀; IB the same, but receptacle ♂; IA1, IA2, etc, IB1, IB2, etc, the same.

Equisetum limosum I, cormoid rhizome: Ca; I 1, I 2, etc, the same (from I, I 1, I 2, etc): Ca; II, complete cormus-individual (from I, I 1, 1 2, etc): Ca, F, R-strobilus, neutral.

Paris quadrifolia I, cormoid rhizome: Ca; II, complete cormus-individual: Ca, F, R-flower ♂♀.

Viola tricolor I, foliage cormus-individual: Cot, F; II, flowers with pedicels (from I, F): b, R-flower ♂♀.

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[1]) The examples mentioned in the text were carefully worked out and will for the most part prove to be correct. Nevertheless if a reader should be able to check some of them by direct observation it is not impossible that this might lead to some corrections, for it proved difficult to find in botanical literature the necessary facts for working out some of these formulae.

[2]) A.Braun l.c. p. 93 mentions that sometimes the axils of the two bracteoles may produce a flower whose pedicel is again provided with two bracteoles and he considers these flowers as impoverished non-essential cormus-individuals.

Orobanche ramosum I, incomplete cormus-individual: Ca, B; II, flowers (from I: B): b, R-flower ♂♀.

Equisetum arvense I, cormoid rhizome: Ca; I 1, I 2, etc, the same: Ca; IIA, foliage cormus: Ca, F; IIA1, IIA2, etc, the same: F; IIB, fertile cormus-individual: Ca, R-strobilus, neutral.

Polytrichum juniperinum IA, IB, cormoid rhizome of female and male plants: Ca; IIA, complete cormus-individual: Ca, F, R-cormoid receptacle ♀ ; IIB, the same, but receptacle ♂.

Hypnum intermedium Lindb. IA, IB, foliage cormus of female and male plants: F, paraphyllia: IA1, IA2, etc, IB1, IB2, etc, the same; IIA, cormoid receptacle (from IA, IA1, IA2, etc) ♀ ; IIB, cormoid receptacle (from IB, IB1, IB2, etc) ♂.

Lythrum Salicaria IA, IB, IC, leafy stem of the three forms: Cot, F, B; IA 1, IA2 etc, IB1, IB2, etc, IC1, IC2, etc, the same: F, B; IIA, IIB, IIC, flowers of the three forms: b, R-flower ♂♀.

Secale cereale I, foliage cormus: F, B; II, spikelet (from I: B): B; III, flower (from II: B): b, R-flower ♂♀.

Veronica Chamaedrys I, foliage cormus: Cot, F; I 1, I 2, etc. (from I, I 1, I 2, etc: F): Ca, F; II peduncle (from I, I 1, I 2, etc, F): B; III flowers with pedicels (from II: B): b, R-flower ♂♀.

Daucus Carota I, radical rosette: Cot, F; PS1, annual shoot of the second year, foliage cormus: F, Inv; II, partial umbel (from I, Inv): inv; III, flower ♂♀.

Juglans regia I, foliage cormus: Cot, Ca, F; PS1, PS2, etc, foliage annual shoots: Ca, F...; PSn, flowering annual shoot: Ca, F, B; I 1, I 2, etc, like I, PS2 till PSn; IIA female flower (from I, PSn: B): b, R-flower ♀ ; IIB, male spike (from I, PSn-1): B; III, flowers: b, R-flower ♂.

Climacium dendroides I, cormoid rhizome: Ca; II, foliage cormus individual: Ca, F, paraphyllia; IIIA, R-cormoid receptacle ♀ ; IIIB, R-cormoid receptacle ♂.

Trifolium montanum I, short foliage cormus-individual: Cot, F; PS1, PS2, etc, the same: F; II, elongated foliage cormus-individual (from I: F): Ca, F; III, peduncle (from II: F): B; IV R-flower ♂♀.

Phoenix dactylifera IA, IB, trunk of female and male individual: F; IIA, IIB, primary peduncle: SP, B; IIIA, IIIB, peduncle branches of first order (from II: B): B; IVA R-flower ♀ ; IVB, R-flower ♂.

S. No. 253. (cf. S. No. 240). Spatial relations between caulomes, phyllomes and cormus-individuals. Concerning these relations the following subjects will be dealt with:

1a. phyllotaxy. See S. No. 254.
1b. vernation. See S. No. 257.
1c. aestivation and plication. See S. No. 258.
1d. spatial relations in a cormoid system between lateral branches and their podia. See S. No. 266.

S. No. 254. (cf. S. No. 253). Concerning phyllotaxy the following subjects will be dealt with:

1a. definition of the term and general considerations. See S. No. 255.
1b. phyllotactical terms. See S. No. 256.

S. No. 255. (cf. S. No. 254). Phyllotaxy[1]. This term designates the reciprocal arrangement of the places of insertion of phyllomes on the caulome.

The most important fact in this respect is that the place of the phyllomes in vascular plants, most *Bryophyta* and a few *Thallophyta (Sargassum)* is connected with the place of lower earlier produced phyllomes and that in most seed-plants the place of the first phyllomes on the primary caulome of the seedling is connected with the symmetry of the seed, whilst the place of the prophylls of the lateral cormus-individuals is connected with the spatial relations of podium and subtending phyllome.

In consequence of the facts mentioned above the arrangement in phyllotaxy tends to become more or less regular; irregular arrangements appear exceptionally in many species of plants, as a rule only in a few cases *(Acorus Calamus,* spadix; *Pandanus* spp., female inflorescence). A very high grade of regularity is reached for instance in the cones of *Coniferae* and the heads of *Helianthus annuus*. The phyllotaxy in vegetative regions is often more variable than that in inflorescences and flowers. A high degree of conformity in plants belonging to allied systematic groups is of common occurrence in the spatial relations of prophylls belonging to inflorescences and the floral phyllomes immediately following; these phenomena are of course very important and have often been thoroughly investigated.

In cases of regular phyllotaxy the phyllomes are always inserted in definite rows running in different directions and called parastichies (cf. S. No. 42); on adult cylindrical caulomes they are helices (speaking mathematically). Each parastichy contains either all the phyllomes of the caulome or the 1/n part of them. In the latter case there exist other similar parastichies parallel to the one first mentioned and their number is n—1; these n parastichies comprising together all the phyllomes, are called a set of parastichies.

From the above observations we may draw the conclusion that cases of regular phyllotaxy exhibit a certain resemblance to special regular mathematical lattices.

The members constituting each parastichy are originally always placed at equal distances from one another; if the original longitudinal relations of the caulome should be altered by subsequent growth in length, the horizontal distance between the phyllomes in that parastichy — the so-called secondary divergence — nevertheless remains the same. This secondary divergence is expressed in degrees or in parts of the circumference of a circle.

Vertical parastichies running parallel to the axis of the caulome are called orthostichies (cf. S. No. 42).

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[1] For this article I am indepted to the most competent pen of my colleague Dr. J. C. Schoute. See also morphological note No. 19.

For determining the principal characters of phyllotaxy it is necessary in the first place to count out the number of parastichies belonging to each of the two most conspicuous antidromous sets of parastichies and here we may distinguish:

1a. spiral or scattered arrangement (spiralis, sparsus). The numbers of the two sets are different and have no common divisor. In this case all phyllomes are inserted in different levels; the spiral line which unites the phyllomes according to their ascending insertions taking the shortest way is a parastichy and this parastichy is called genetic spiral (cf. S. No. 43) or basal spiral and its divergence is called the basal divergence of phyllotaxy or simply divergence without any addition (cf. S. No. 48). By this divergence the phyllotaxy is completely determined with respect to its most important characters. The successive members can also be united by an antidromous spiral line and in this case the divergence surpasses one half of the caulome circumference; this is called the genetic spiral according to the long way (abbreviated L. W.), in contrast with that according to the short way (abbreviated S. W.).

In the great majority of cases the numbers of both sets of parastichies which are counted out, belong to the main series 1 1 2 3 5 8 etc. (series of Fibonacci), in a small part of the cases they belong to the so-called first accessory series 1 3 4 7 11 etc., in rare cases they belong to other series of the same kind, of which always every term is formed by the sum of the two preceding ones.

Example of the main series: *Pinus austriaca,* cone: the object figured by Church ¹) exhibiting 8+13 parastichies.

Example of the first accessory series: *Sedum reflexum,* foliage cormus: the object figured by Church ²) exhibiting 3+4 parastichies and furthermore a set of 7 very steep parastichies.

The divergence of systems of the main series may vary between 128° and 180°, in cases with higher numbers of parastichies it is usually confined between the limits 135° and 140°. Yet the divergence may be different in cases with the same sets of parastichies; Braun figures ³) three cones of *Pinus austriaca Du Roi (Abies excelsa de Candolle)* all three with 5+8 parastichies and yet with the divergences 8/21 (fig. 1), 13/34 (fig. 2), and 18/47 (fig. 4).

The divergence of systems of the first accessory series is always smaller, and remains in the vicinity of 100°.

If there are orthostichies the divergence is a rational fraction of the circumference of the circle. A special term for a frequently occurring case of this kind is:

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¹) Church. On the relation of phyllotaxis to mechanical laws. London 1904, plate II, fig. 5.

²) Church, l. c. pl. 24.

³) Alex. Braun. Vergleichende Untersuchung über die Ordnung der Schuppen an den Tannenzapfen als Einleitung zur Untersuchung der Blattstellung überhaupt (commonly cited as "Tannenzapfen"). Akad. Caes. Leopoldina, vol. 15, 1830, Taf. XXIII, fig. 1, 2, 4.

2a. distichous arrangement (distichus). The divergence is indicated by the fraction $^1/_2$. *Ulmus campestris,* foliage cormus.

2b. tristichous arrangement (tristichous). The divergence is indicated by the fraction $^1/_3$. Occurs rarely in a relatively pure form, though approximations to it are not uncommon: *Alnus glutinosa,* foliage cormus, *Pandanus utilis,* foliage cormus.

2c. quincuncial arrangement (quincuncialis). The divergence is indicated by the fraction $^2/_5$. Approximations are of very common occurrence.

Divergences of $^3/_8$, $^5/_{13}$, $^4/_{11}$ and others may occur, but have not given rise to special terms.

1b. jugate arrangement (jugatus). The numbers are different and have a common divisor. A certain number of phyllomes is successively inserted at the same level and their number is the same as the number of units contained in the common divisor; there is no genetic spiral, the set consisting of the smallest number of parastichies contains the number of parastichies indicated by the divisor. The numbers belong to series which are multiples of those mentioned under 1a; the most common ones are multiples of the main series, like 2 2 4 6 10 16 etc. Examples of this kind are to be found occasionally in many different kinds of plants (cones of *Coniferae);* in *Dipsaceae* this arrangement is of most common occurrence: *Dipsacus pilosus* [1]), inflorescence, number of parastichies 10+16 and *Dipsacus sylvestris* [2]), seedling rosette, number of paratichies 2+4.

According to the common divisor we may distinguish:

2a. bijugate arrangements. The divisor = 2.

2b. trijugate arrangements. The divisor = 3.

2c. multijugate arrangements. The divisor = more than 3.

1c. whorled or verticillate arrangement (verticillatus). The numbers of both sets are the same. Successive whorls of phyllomes, each containing as many members as is indicated by the numbers which have been found. Examples: *Lycopodium Selago* [3]), number of parastichies 3+3 and 3+3 changing to 4+4. Here we may distinguish:

2a. whorls containing n members together form n orthostiches, so that there is superposition of the whorls. Examples are relatively rare and are afforded by foliage cormi of *Archaecalamites, Sphenophyllinae,* moreover by epipetalous stamens in obdiplostemonous flowers and by stamens in many *Monochlamydeae.*

2b. Whorls containing n members together form 2n orthostiches, so that there is alternation of whorls. This arrangement is of most common occurrence and for a special case the following terms are in use:

3a. decussate arrangement (decussatus). Whorls containing two members combined with alternation. Here we may distinguish:

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[1]) Church, l. c. plate XVIII, fig. 60b.

[2]) Church, l. c. plate XIX, fig. 61b.

[3]) Church, l. c. p. 205, fig. 80.

4a. Caryophyllaceous decussate arrangement. The two phyllomes of each pair are different, either because one phyllome is inserted on a somewhat higher level or is somewhat more strongly developed or again because its axillary bud shows stronger development than that of the other one. The phyllomes exhibiting the same position or grade of development are placed on a parastichy with a secondary divergence of $^1/_4$. Family of *Caryophyllaceae.*

4b. Fraxinus decussate arrangement. The two phyllomes of each pair are different as in 4a, but those of the same kind are all arranged in a zigzag line on one side of the caulome and belong to two of the four orthostiches. Hence the cormus is more or less dorsiventral. *Fraxinus* and *Cuphea,* foliage cormi.

See moreover M. N. No. 19.

S. No. 256. (cf. S. No. 254). Phyllotactical terms. In phyllotaxy the following elementary terms are generally used:

1a. spiral arrangement. See S. No. 43.

2a. scattered arrangement (sparsus). *Populus pyramidalis, Ribes sanguineum,* foliage cormi; *Pinus,* cone. See moreover S. No. 48.

3a. distichous arrangement (distichus). The divergence is indicated by the fraction $^1/_2$. *Ulmus campestris,* foliage cormi.

1b. cyclic arrangement. See S. No. 43.

2a. decussate arrangement (decussatus). Each node bears two phyllomes (opposite phyllomes, folia opposita) and the successive pairs are alternately placed at right angles with respect to one another. *Lamium album, Acer Pseudo-Platanus,* foliage cormi.

If cormi with decussate phyllomes are inclined horizontally, the phyllomes may be placed in two instead of four rows by twisting of petioles and internodes, but the arrangement of their insertions remains the same. *Philadelphus coronarius, Deutzia scabra,* horizontal cormi.

2b. whorled arrangement (verticillatus). Each node bears three or more phyllomes. *Nerium Oleander, Juniperus communis, Elodea canadensis, Hippurus vulgaris, Equisetum,* foliage cormi; many floral phyllomes. See S. No. 380.

S. No. 257. (cf. S. No. 253). Vernation (vernatio). This term designates the mode in which individual phyllomes may be bent, folded or coiled. These phenomena result from growth of the primordia and may often be more or less effaced in the adult state. Hence many complex examples are furnished by buds in a certain stage of development, although vernation in itself is a phenomenon occurring also in a mature state.

With respect to vernation phyllomes may be:

1a. plain. *Reseda,* calyx and corolla; *Coniferae,* scales of cones; it is the ordinary case in mature foliage leaves.

1b. folded (plicativus).

2a. conduplicate (conduplicativus, conduplicatus). Folded lengthwise on the midrib, so that the phyllome is doubled up, the upper face being inside. *Syringa vulgaris, Quercus,* foliage leaves in the bud; *Leguminosae* and *Liliaceae,* carpids (in combination with concrescence).

2b. plicate or plaited (plicativus, plicatus). Folded on the primary veins in the manner of a closed fan, *Ribes, Vitis vinifera,* many *Palms, Fagus sylvatica, Alchemilla, Veratrum,* foliages leaves in the bud; *Aesculus Hippocastanum,* leaflets in the bud; *Scrophulariaceae,* petals.

2c. induplicate (induplicativus, induplicatus). Both margins are bent abruptly inwards. *Clematis Virginiana,* calyx; *Papaver, Colchicum autumnale, Gentiana, Scrophularia nodosa,* carpids (in combination with concrescence).

2d. reduplicate (reduplicativus, reduplicatus). Both margins are bent more or less abruptly outwards. Some *Malvaceae* and *Comarum palustre,* calyx.

2e. corrugate, wrinkled or crumpled (corrugatus, corrugativus). Folded up irregularly. *Rheum,* foliage leaves; *Papaver,* petals.

2f. reclinate, inclinate, replicate or inflexed (reclinatus). The blade bent downwards upon the petiole. *Liriodendron tulipifera; Aconitum, Anemone,* foliage leaves.

1c. rolled up (volutivus).

2a. involute (involutus, involutivus). Both margins rolled up spirally towards the midrib on the upper face of the phyllome. *Nymphea alba, Viola tricolor, Populus, Pirus, Sambucus, Lonicera, Weigelia, Alisma,* foliage leaves; *Steironema* and *Tremandra,* petals; *Pyrola secunda, Citrullus colocynthis,* carpids (in combination with concrescence).

2b. revolute (revolutivus, revolutus). Both margins rolled up spirally towards the midrib on the lower face of the phyllome. *Cycas revoluta, Azalea, Rosmarinus officinalis, Polygonum, Rumex, Salix, Nerium Oleander, Clematis,* foliage leaves.

2c. convolute or supervolute (convolutivus, convolutus). Wholly rolled up from one margin, so that one margin is within the coil, the other without. *Prunus domestica, Prunus Armeniaca, Musa, Berberis, Canna, Convallaria,* foliage leaves.

2d. circinate or circinal (circinatus). Rolled spirally from the apex downwards, the coil is mostly turned towards the upper face of the phyllome, sometimes towards the lower surface and in the latter case the term vernatio retrorsum circinate[1]) is sometimes used. True *Ferns,* foliage leaves; *Bowenia spectabilis,* rhachis and leaflets; *Zannichellia,* cotyledons; *Drosera,* foliage leaves; *Drosophyllum lusitanicum,* foliage leaves (retrorsum in contrast with *Drosera).*

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[1]) Oudemans en de Vries, Leerboek der Plantkunde, vol. II, part I, Vormleer by Oudemans, Nijmegen 1895, p. 90.

See moreover M. N. No. 20.

S. No. 258. (cf. S. No. 253). Concerning the term aestivation the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 259.
1b. open and closed aestivation. See S. No. 260.
1c. closed aestivation: mode of contact. See S. No. 261.
1d. transverse and longitudinal aestivation. See S. No. 262.
1e. kinds of transverse aestivation. See S. No. 263.
1f. kinds of longitudinal aestivation. See S. No. 264.
1g. plications or plaits. See S. No. 265.

S. No. 259. (cf. S. No. 258). Aestivation (aestivatio). This term designates the reciprocal dispositions of the phyllomes. This is in some respects the result of phyllotaxy. But its more essential characters are the consequences of growth of the phyllomes, when the originally free primordia meet together in several ways with their apices, bases or margins. In many cases subsequent growth of the axis afterwards removes the phyllomes from one another. Hence many complex examples are furnished by buds in a certain stage of development, though aestivation in itself is a phenomenon occurring also in a mature state. In maturity however the distance between the phyllomes may often be so augmented, that in descriptions there is no longer need to mention aestivation; this for instance is the case with most cormi bearing foliage leaves. (cf. S. No. 245).

In near relation to aestivation stand:

plications or plaits in the wall of a tube or cup considered as arising by concrescence of several phyllomes into one body. See S. No. 265.

See moreover M. N. No. 20.

S. No. 260. (cf. S. No. 258). With respect to the distance of the phyllomes from one another we may distinguish:
1a. an open or indeterminate aestivation (aestivatio aperta). The members are not in contact with one another. For examples see S. No. 263.
1b. a closed aestivation. The members are in contact with one another. See S. No. 261.

S. No. 261. (cf. S. No. 258). In closed aestivation we may distinguish with respect to the mode in which the phyllomes come into contact:
1a. a valvular aestivation (aestivatio valvaris). The lateral margins of the phyllomes meet without any overlapping. See S. No. 263.

1b. an imbricative aestivation (aestivatio imbricativa). Contiguous phyllomes overlap one another. Generally phyllomes which are of higher insertion on the axis will be overlapped or even inclosed, but such overlappings may often be reversed, either regularly and congenitally (see S. No. 264) or occasionally as a consequence of accidental circumstances during growth (metatopy) (see S. No. 263).

S. No. 262. (cf. S. No. 258). With respect to the direction of aestivation we may distinguish:
1a. transverse aestivation. This is concerned only with the reciprocal positions of phyllomes in a direction transverse to the longitudinal axis of the caulome. Here the aestivation may be open, valvular or imbricative. The latter case is the most important and is the consequence of overlapping of the lateral margins of contiguous phyllomes, which may often occur together with a spiral phyllotaxy, though phyllomes which are placed in whorls generally show it in a more distinct and lasting manner. See S. No. 263.
1b. longitudinal aestivation. This is concerned only with the reciprocal positions of the phyllomes in a more or less longitudinal direction. Here the aestivation is always imbricative, so that each phyllome overlaps the next higher or lower one. See S. No. 264.

S. No. 263. (cf. S. No. 258). Transverse aestivation. Here we may distinguish:
1a. open aestivation. (cf. S. No. 260). *Coriandrum sativum* and many other *Umbelliferae,* calyx; *Reseda odorata, Rhamnus,* corolla.
1b. closed aestivation. (cf. S. No. 260).
2a. valvular aestivation or valvate phyllomes (valvaris, valvatus) (cf. S. No. 261). *Tilia, Malva, Rhamnus, Fuchsia, Philadelphus,* calyx; *Hedera Helix, Mimosaceae,* corolla.
In combination with vernation we may distinguish:
3a. valvular-induplicate aestivation, valvate-induplicate phyllomes (cf. S. No. 257). *Clematis Virginiana,* calyx: *Ampelidaceae,* corolla; *Papaver somniferum* and *Scrophularia nodosa,* carpels (in combination with concrescence).
3b. valvular-reduplicate aestivation, valvate-reduplicate phyllomes (cf. S. No. 257). Some *Malvaceae* and *Comarum palustre,* calyx.
3c. valvular-involute aestivation, valvate-involute phyllomes. (cf. S. No. 257). *Clematis Viticella,* calyx; *Pyrola secunda* and *Citrullus colocynthis,* carpels (in combination with concrescence).
2b. imbricative aestivation or imbricate phyllomes (cf. S. No. 261). Often this aestivation may be characterized by the fraction which indicates the divergence of a spiral arrangement. It is moreover a fact that in many cases of cyclic arrangement

an aestivation appears which answers to a certain spiral arrangement, as if the whorl were a depressed spiral and of these cases examples will be given below. Further in special cases the following terms are used:

3a. quincuncial aestivation (quincuncialis). This corresponds to the complete horizontal projection of a spiral $^2/_5$ arrangement: the first and second phyllomes being external, the fourth and fifth internal and the third with one margin internal and the other external. Metatopy is by no means rare. *Rosa gallica, Astrantia, Eryngium,* calyx; *Passiflora coerulea* and *Berberis,* corolla.

3b. cochlear aestivation (cochlearis). Here of 5 phyllomes one is wholly external, one wholly internal and three with one margin internal and the other external; it is intermediate between the quincuncial and the contorted aestivation. Deviations are by no means rare. *Phacelia, Primula,* many *Asperifoliaceae,* corolla.

3c. contorted or twisted aestivation[1]) (contortus). Here each phyllome successively overlaps a preceding and is overlapped by a following one, all having a slight and equal obliquity of position and appearing rolled up together. *Malvaceae, Onagraceae, Apocynaceae, Gentianaceae, Polemoniaceae,* corolla. It may be to the right (dextrorse) or to the left (sinistrorse): if for an observer standing on the outside the overlapping margins of the phyllomes turned towards him are on his right side the aestivation is called dextrorse, if on the left side sinistrorse. *Linum usitatissimum,* calyx quincuncial, corolla contorted, both turned the same way in the same flower, but in different ways in different flowers.

3d. equitant aestivation and phyllomes (equitativus, equitans). Here conduplicate (cf. S. No. 257) phyllomes successively more or less clasp those placed more towards the apex. The typical example is that of distichous phyllomes, like the foliage leaves of *Iris* showing this aestivation at least at their base. Another example is afforded by the equitant-triquetrous (trifariam equitans) aestivation of *Carex,* foliage leaves, where the divergence is indicated by the fraction $^1/_3$ and the leaves are imperfectly conduplicate.

3e. vexillary or descendant aestivation (descendens). Here posterior phyllomes successively overlap anterior ones. *Leguminosae, Violaceae, Scrophulariaceae,* corolla.

3f. ascendant aestivation (ascendens). Here anterior phyllomes successively overlap posterior ones. *Caesalpiniaceae,* corolla.

S. No. 264. (cf. S. No. 258). Longitudinal aestivation. Here we may distinguish:

1a. succubous phyllomes. The phyllomes are overlapped by the lower ones.

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[1]) Some authors call this a convolute or obvolute aestivation. Asa Gray, Bot. Text-book, P I, New York 1849, p. 138.

2a. apically. The overlapping part is the apex of the phyllome. *Helianthus annuus,* involucre; *Dioon edule,* macrosporophylls; *Pinus Laricio,* microsporophylls; *Pinus sylvestris,* scales of cone; calyx and corolla of many flowers.

2b. laterally. The overlapping part is the anterior margin of the phyllome, which is obliquely directed towards the apex of the axis. *Frullania Tamarisci,* foliage leaves.

1b. incubous phyllomes. The phyllomes are overlapped by the higher ones.

2a. apically. The overlapping part is the apex of the phyllome. *Encephalartos villosus,* macrosporophylls; *Calamus,* fruits: appendages of the outer surface[1] (cf. S. No. 73).

2b. laterally. The overlapping part is the posterior margin of the phyllome, which is obliquely directed towards the apex of the axis. *Plagiochella asplenioides,* foliage leaves.

S. No. 265. (cf. S. No. 258). Plications or plaits in the wall of a tube or cup considered as arising by concrescence of several phyllomes into one body. These plaits may be:
1a. outwardly salient. *Campanula,* corolla.
1b. internal. *Gentiana,* corolla.
1c. straight. *Campanula, Gentiana,* corolla.
1d. supervolute. The plaits overlap one another in a convolute way. *Convolvulus* and *Datura,* corolla.
1e. spirally twisted. *Ipomoea purpurea,* corolla.

S. No. 266. (cf. S. No. 253). Concerning the spatial relations in a cormoid system between lateral branches and their podia the following subjects will be dealt with:
1a. relations between lateral cormus-individuals (or cormoid buds) and certain phyllomes belonging to their podia. See S. No. 267.
1b. relations between the prophylls of a branch, and its podium. See S. No. 268.
1c. relations between the disposition of the prophylls and that of the higher placed phyllomes of the branch. See S. No. 269.
1d. relation between the phyllotaxy of the higher placed phyllomes of the branch and that of its podium. See S. No. 272.

See moreover M. N. No. 21.

S. No. 267. (cf. S. No. 266). Spatial relations between lateral cormus-individuals (or cormoid buds) and certain phyllomes belonging to their podia. Terminal buds, adventitious buds (cf. S. No. 65) and the cormi produced by both do not exhibit relations of this kind. On the other hand it may be considered a general rule, that normal lateral buds have a strong tendency to appear on the caulomes in the vicinity of a phyllome or even on the phyllome itself and that the reciprocal positions of phyllomes and buds, although different in various cases, nevertheless exhibit certain fixed spatial relations peculiar to certain plants or certain cormi.

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[1] Though these parts are not phyllomes their reciprocal positions may well be described by using the term mentioned in the text.

In these respects we may distinguish:

1a. axillary buds or branches and subtending phyllomes. The normal lateral buds in *Monocotyledons, Dicotyledons, Gymnosperms* and some *Ferns (Trichomanes brachypus)* spring from the axil (cf. S. No. 57) of the phyllome and this very constant relation is designated by the terms axillary buds and branches; the phyllome in the axil of which a bud or branch develops, is called its subtending phyllome. Axillary buds are mostly placed in the median plane and as a rule only a single bud is produced in the axil of each subtending phyllome. Further we may distinguish the following special cases:

2a. serial buds. Two or more buds are developed in the axil one above another[1].

3a. descending serial buds. The upper bud is the oldest one and the lower are successively younger; this is the most general case. *Aristolochia Sipho; Gleditschia; Gymnocladus canadensis; Sisymbrium polyceratium,* flowers in the axils of leaves.

3b. ascending serial buds. The lowest bud is the oldest one and the upper are successively younger; this is somewhat rare. *Lonicera; Fuchsia coccinea,* flowers; *Viola tricolor,* small vegetative bud on the stem just above the flower.

2b. collateral buds. Two or more buds are developed in the axil side by side. *Muscaria botryoides* and species of *Allium.*

2c. intrapetiolar buds. The axillary bud is so completely surrounded by the base of the petiole, that it cannot be seen till after the fall of the leaf. *Platanus; Rhus typhinum; Virgilia lutea.*

2d. the axillary bud is placed on the caulome somewhat above the subtending phyllome. *Trichomanes rupestris.*

2e. the bud is placed on the upper side of the petiole. *Hymenophyllum valvatum.*

2f. displaced subtending phyllomes. In the majority of cases the subtending phyllomes of axillary buds remain in their places, when those buds develop. But sometimes a displacement (cf. S. No. 136) of the subtending leaf occurs, so that it is lifted up by the growth of the axillary bud and becomes an essential part of the lateral branch. Examples of this kind are afforded by *Datura Stramonium,* where the subtending leaves of the two lateral branches under each flower are displaced; by *Atropa Belladonna,* where only the larger of these two leaves produces an axillary branch and is displaced; by *Nymphaea alba,* where the subtending phyllome of the flower is displaced and becomes the first sepal.

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[1] Velenovsky, Vergleichende Morphologie der Pflanzen, II Teil, Prag 1907, p. 687, gives a profusion of interesting examples. Richter, Jahrb. d. Kgl.-bot. Gart. Berlin I, 1881, p. 148.

1b. a certain number of well-defined cases for which no special terms are in use.

2a. in cases of true dichotomy the ramification almost constantly appears in the neighbourhood of a phyllome called angular leaf¹) as is exhibited by *Ferns, Lycopodinae* and *Palms;* it is placed on one end of the saddle of the dichotomy (cf. S. No. 58). *Lygodium scandens; Selaginella bella* and *Apus* (Velenovsky l.c. p. 249, 214 and 259); *Hyphaene* ²).

2b. the lateral buds are placed below the base of a phyllome. *Fontinalis antipyretica* (in the median plane), *Sphagnum* (laterally below one half of the leaf) *Lejeunia, Radula* ³), *Cibotium Schiedei* ⁴).

2c. the lateral buds appear in the place of one half of a leaf beside the remaining half. Many *Jungermanniae,* for instance *Frullania, Mastigobryum, Jungermannia trichophylla.*

2d. the lateral buds are placed at the side of the leaves. *Equisetum* (between the teeth of the leaf-sheath at the same level with it), *Hymenophyllum interruptum* and *Davallia mucronata* (obliquely above the side of the leaf), *Adianthum curvatum* (obliquely below the side of the leaf).

2e. the lateral buds are placed on the underside of the petiole. *Pteris aquilina.*

S. No. 268. (cf. S. No. 266). Spatial relations between the prophylls of a branch and its podium. Here we may distinguish the following cases:

1a. there is but a single prophyll, which is often placed on the adaxial or dorsal side of the lateral cormus-individual and may then be called an adaxial prophyll. Examples are afforded by most *Monocotyledons* in their vegetative cormus-individuals as well as in their flowers, where the prophyll is called a bracteole. These prophylls often exhibit instead of a single midrib two lateral nerves, as in the vegetative region of *Secale cereale.*

1b. there are two prophylls, which are generally placed transversely to the right and left. They are sometimes inserted at the same level and than they may be of the same age, but in other cases there may be means of ascertaining that they nevertheless are not of the same age and in other cases again this may be proved by their insertion at different levels. If difference of age can be established, the older one is called α and the younger β. Examples are afforded by the majority of Dicotyledons and Gymnosperms; in the reproductive

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¹) Velenovsky. Vergl. Morph. d. Pfl. Prag. 1905, I Teil, p. 249 and Schoute, Ueb. verästelte Baumfarne und die Verästelung der Pteropsida im algemeinen, Receuil d. Trav. bot. néerlandais, vol. XI, 1914.

²) Schoute. Die Verästelung von Hyphaene. Receuil d. Trav. bot. néerlandais, vol. VI, 1909.

³) Sachs. Lehrbuch 4. Aufl. 1874, p. 177 and for Bryophyta Leitgeb, Sitzungsber. K. Akad. d. Wiss. 1868, B. 57 and 1869, Bd. 59, and Bot. Zeitg. 1871.

⁴) For this and the following examples of Ferns see Mettenius, Ueber Seitenknospen bei Farnen, Abh. d. K. Sächs. Gesellsch. d. Wiss. Leipzig, 1861, Bd. 5, p. 611.

region they often appear as bracteoles, as on the pedicels of lateral dicotyledonous flowers (see S. No. 306).

S. No. 269. (cf. S. No. 266). With respect to the spatial relations between the prophylls and the more highly placed phyllomes of the branch the following subjects will be dealt with:
1a. general survey of these relations. See S. No. 270.
1b. special relations in cases of spiral phyllotaxy. See S. No. 271.

S. No. 270. (cf. S. No. 269). General survey of the spatial relations between the prophylls and the more highly placed phyllomes of the lateral branches of higher plants. The spatial relations between the prophylls and the phyllotaxy of the more highly placed phyllomes on lateral branches, although in a general way occurring in many modifications, are nevertheless often constant for a given species or even for larger groups of plants. Hence in descriptions aiming at a certain degree of completeness the mode of junction between prophylls and the phyllotaxy of the higher phyllomes ought to be mentioned. Concerning this subject only a very few special terms are in use, to be dealt with in S. No. 271. But it is necessary to mention some of the principal modes of junction (in German: Einsatz or Anschluss). According to Eichler we may distinguish the following cases:
1a. prophylls wanting.
  2a. typically wanting, which means that their places are not empty, but that they have been metamorphosed. It is in this case a general rule, at least in Dicotyledonous flowers, that the two first phyllomes of the cormus-individual, mostly the two first sepals, take the transverse positions of two prophylls (Eichler's Einsatz). *Francoa* (four sepals); *Orchideae* and *Musa* (three sepals); *Primulaceae, Reseda* (five sepals). Eichler, Blüthendiagramme p. 31, Th. I.
  2b. wanting in consequence of abortion. The phyllomes of the cormus-individual take their positions just as if the prophylls were present (Eichler's Anschlusz). Blüthendiagramme I p. 31. *Cruciferae.*
1b. prophylls present. (Eichler's Anschlusz).
  2a. spiral phyllotaxy.
    3a. a single prophyll.
      4a. divergence of phyllotaxy $^1/_3$. The first phyllome is generally placed opposite the prophyll. Thus an adaxial prophyll corresponds to a first phyllome placed on the abaxial side in the median plane. *Irideae,* flowers. If the prophyll is placed obliquely or even in the transverse plane the same rule holds good in a general way, but displacements in relation with the median symmetry may occur. Blüthendiagramme I p. 25.
      4b. divergence of phyllotaxy $^2/_5$. The divergence between prophyll and first higher phyllome may be $^2/_5$, but also $^1/_2$ and transitional cases between both extremes may occur. Examples are afforded only by *Dicotyledons* and are not of common occurrence:

flowers of *Ranunculus auricomus* and other species of the same genus. Blüthendiagramme I p. 26.

3b. two prophylls.

4a. divergence of phyllotaxy $^1/_3$. The position of the first higher phyllome with respect to the prophyll β is usually obliquely opposite β with a divergence of about 150° *(Cinnamomum, Amarantus, Menispermum, Rumex, Galanthus,* flowers); in rare cases it is right opposite β *(Elodea canadensis,* flower); in vegetative branches it may often be 90°. Blütendiagramme I p. 27.

4b. divergence of phyllotaxy $^2/_5$. The first higher phyllome is often placed obliquely opposite the prophyll β with a divergence of about 126°, so that the second phyllome lies in the median plane, either adaxial or abaxial (majority of Dicotyledonous calyces sepal 2 adaxial; abaxial in *Lobeliaceae* and *Rhodoraceae).*

In other cases the divergence between β and sepal 1 is smaller, so that sepal 1 itself falls in the median plane *(Papilionaceae, Caesalpiniaceae);* intermediate cases between this and the normal case occur *(Andromeda calyculata).* Blüthendiagramme I p. 23.

2b. cyclic phyllotaxy.

3a. a single adaxial prophyll. Blüthendiagramme I p. 26.

4a. dimerous whorls. The first whorl is placed transversely. Casually in some flowers of *Irideae.*

4b. trimerous whorls. One of the three members of the first whorl is placed in the median plane, either adaxial *(Bambusa)* or abaxial (common case).

3b. two transversely placed prophylls. Blüthendiagramme I p. 29.

4a. dimerous whorls. The first whorl is placed in the median plane. *Cruciferae* and *Onagraceae,* calyx.

4b. trimerous whorls. One member of the first whorl is mostly adaxial.

4c. tetramerous whorls.

5a. the first whorl is placed in a median-transverse cross, and is then suspected to consist of two dimerous whorls. *Stellatae.*

5b. the first whorl is placed in a diagonal cross.

6a. it is a true tetramerous whorl.

6b. it arises in consequence of abortion out of a pentamerous whorl. *Veronica* and *Rhinanthus,* calyx.

4d. pentamerous whorls. The first whorl exhibits the same mode of junction as in the case of a spiral phyllotaxy with the divergence $^2/_5$ (cf. 2a, 3b, 4b). Blüthendiagramme p. 30.

S. No. 271. (cf. S. No. 269). With respect to the mode of junction between the single or the β prophyll and the first higher phyllome in the spiral phyllotaxy of a branch we may distinguish:

1a. an emprosthodromous cormus-individual (flower)[1]. This term designates that the genetic spiral of the branch is assumed to pass on its shortest way from the last prophyll to the first higher phyllome of the branch on the abaxial side of the branch. In flowers this junction is of the most common occurrence: *Convolvulaceae, Hypericeae, Linaceae, Hemerocallis, Scilla;* an example of vegetative branches with two prophylls is afforded by *Peperomia pulchella*[2].

1b. an opisthodromous cormus-individual (flower). This term designates that the genetic spiral of the branch is assumed to pass on its shortest way from the last prophyll to the first higher phyllome of the branch on the adaxial side of the branch. Flowers of *Lobeliaceae* and *Rhodoraceae;* an example of vegetative branches with one prophyll is afforded by *Peperomia blanda*[3].

S. No. 272. (cf. S. No. 266). With respect to the spatial relation between the spiral phyllotaxy of a branch and that of its podium we may distinguish:

1a. homodromy, homodromous branches. The direction of the genetic spiral is the same in branch and podium. *Hyacinthus orientalis,* successive annual shoots in the bulb; in inflorescences every screw; in dichasia one branch homodromous, the other antidromous.

1b. antidromy, antidromous branches. The direction of the genetic spiral in branch and podium is opposite. In inflorescences every cincinnus; in dichasia one branch antidromous, the other homodromous.

1c. poecilodromy, poecilodromous branches. The direction of the genetic spiral of the branch is independent of that of the podium, so that in a monopodium sister branches may be equally well antidromous as homodromous. In vegetative parts of Dicotyledons very common.

2. Special kinds of cormi, cormoid systems, cormus-individuals and their peculiarly differentiated parts.

S. No. 273. Concerning special kinds of cormoid systems, cormus-individuals and their peculiarly differentiated parts we may distinguish:

1a. foliage cormi, cormoid systems, cormus-individuals and annual shoots or leafy cormi, cormoid systems, cormus-individuals and annual shoots. See S. No. 274.

1b. suckers or gourmandisers. See S. No. 275.

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[1] In all recent botanical publications the meaning of these terms corresponds to the definition given in the text. In an earlier period however both were used in respectively opposite senses. See footnote p. 183.

[2] J. C. Schoute, On whorled phyllotaxis II, Receuil d. trav. bot. néerlandais. Vol. XXII, 1925, p. 161.

[3] J. C. Schoute, l.c. p. 142.

1c. elongated and short or dwarf cormus-individuals. See S. No. 276.
1d. cormoid rhizomes. See S. No. 277.
1e. cladodes, phylloclades or cladophylls. See S. No. 278.
1f. radical rosette. See S. No. 279.
1g. rhizophores. See S. No. 280.
1h. tendrillar cormi or cormoid tendrils. Confer S. No. 193.
1i. cormoid spines. Confer S. No. 192.
1k. cormoid buds. See S. No. 281.
1l. bulbs. See S. No. 285.
1m. cormoid tubers. See S. No. 290.
1n. cormoid fructifications. See S. No. 296.

S. No. 274. (cf. S. No. 273). Foliage cormi, cormoid systems, cormus-individuals and annual shoots or leafy cormi, cormoid systems, cormus-individuals and annual shoots. These terms designate vegetative cormi chiefly consisting of a middle region which is provided with foliage leaves. *Aesculus Hippocastanum* and most other trees.

S. No. 275. (cf. S. No. 273). Suckers or gourmandisers (virga singularis). These terms designate long and strong foliage cormus-individuals arising from dormant or adventitious buds; they develop at the base of the trunks of trees or on shrubs, sometimes having a subterranean origin, but they may also appear from the upper part of tree trunks which have been cut down near the ground or pollarded; under favourable conditions they may afterwards ramify and even grow out into new trees. *Tilia platyphyllos, Salix* and *Populus,* pollarded specimens.

S. No. 276. (cf. S. No. 273). Elongated and short or dwarf cormus-individuals. With respect to differences in length of cormus-individuals belonging to one and the same branch-system we may distinguish:
1a. elongated cormus-individuals (virga). They exhibit a relatively strong and more or less unlimited growth in length.
1b. short or dwarf cormus-individuals (virgula). They arise as lateral branches from elongated cormus-individuals and exhibit a relatively very slight and strictly limited growth in length. Examples are afforded by: *Larix europaea, Pinus Strobus, Pyrus Malus* and *Ribes Grossularia,* in the vegetative region.

Phenomena of a similar kind sometimes occur in thallomes, for instance *Cladostephus verticillatus* and then we may use the terms elongated and short or dwarf podia or branches.

S. No. 277. (cf. S. No. 273). Cormoid rhizomes. (Cf. S. No. 75 and 187). They are provided with mostly soon decaying leaf-scales or leaf-sheaths; their tops may grow out into foliage cormi or the latter may be produced by buds which develop in the axils of the scale-leaves; they often have a strong tendency to ramification, so that very complicated subterranean cormoid systems may ensue. *Climacium dendroides; Polytrichum juniperinum; Equisetum arvense; Triticum repens; Ammophila arundinacea; Carex arenarea; Acorus Calamus; Iris Pseudacorus; Lamium album.*

S. No. 278. (cf. S. No. 273). Cladodes, phylloclades or cladophylls. These terms designate flat, green, leaf-like cormus-individuals consisting of from one to a large number of internodes and mostly exhibiting a limited growth; they may grow in the axils of leaf-scales and in their turn may produce scale-leaves, leaf-spines, branches and flowers. *Phyllocladus; Asparagus officinalis; Ruscus aculeatus; Mühlenbeckia platyclada; Xylophylla; Opuntia brasiliensis.*

S. No. 279. (cf. S. No. 273). The radical rosette[1]). This term designates a cormus-individual or an annual shoot chiefly represented by the middle region which has short internodes and produces an often considerable number of foliage leaves. *Drosera rotundifolia; Bellis perennis; Taraxacum officinale; Beta vulgaris,* annual shoot of the first year; *Agave mexicana* and *atrovirens; Hyacinthus orientalis.*

S. No. 280. (cf. S. No. 273). Rhizophores[2]). This term designates lateral cormus-individuals or cormoid systems (in consequence of ramification); they are cylindrical, elongated and often filiform; they are mostly leafless, although they sometimes bear leaves towards the apex, whilst after removal of parts above them they are capable of growing out into leafy branches; they are mostly colourless, but may be coloured green; although they are of exogenous origin, they produce at their ends true roots of endogenous origin provided with a calyptra. *Selaginella helvetica, S. Martensii.*

S. No. 281. (cf. S. No. 273). Cormoid buds (gemma). Confer for the meaning of this term S. No. 70. Concerning cormoid buds the following subjects will be dealt with:
1a. their position. See S. No. 282.
1b. their contents. See S. No. 283.
1c. their investment. See S. No. 284.

S. No. 282. (cf. S. No. 281). With respect to their position we may distinguish:
1a. terminal buds (terminalis). They are placed at the top of caulomes or their branches.
1b. lateral buds (lateralis). (cf. S. No. 267).
1c. adventitious buds (adventicius). (cf. S. No. 65).

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[1]) Plants with a radical rosette were formerly called stemless plants; the term is inaccurate, superfluous and obsolete.

[2]) Velenovsky. Vergleichende Morphologie der Pflanzen, Prag 1905, I Teil, p. 268.

S. No. 283. (cf. S. No. 281). With respect to their contents we may distinguish:
1a. leaf buds (foliiferus). Containing a foliage or leafy cormus. (cf. S. No. 274). *Fagus sylvatica.*
1b. flower buds (or alabastrum). Containing a flower. *Rosà canina.*
1c. floral buds (gemma florifera). Containing an inflorescence. *Ilex aquifolium.*
1d. mixed buds (mixtus). Containing a cormus with both foliage leaves and a flower or inflorescence. *Aesculus Hippocastanum, Syringa vulgaris.*

S. No. 284. (cf. S. No. 281). With respect to their investment we may distinguish:
1a. naked buds (nudus). A special investment is wanting, *Rhamnus Frangula;* the buds of herbaceous cormi which develop during summer.
1b. scaly buds (clausus). Invested by a perule (perula) which consists of more or less leathery scales (tegumentum). These scales are scale-leaves arising from sheaths, petioles, blades or stipules, whilst metamorphoses back to foliage leaves may occur. *Pavia; Ribes sanguineum; Alnus glutinosa.*

S. No. 285. Bulbs (bulbus), (cf. S. No. 273). See for the meaning of this term S. No. 75. Concerning bulbs the following subjects will be dealt with:
1a. subterranean and aerial bulbs. See S. No. 286.
1b. the general construction of the bulb: monopodial, sympodial and mono-sympodial. See S. No. 287.
1c. the parts of the bulb. See S. No. 288.
1d. tunicated and naked bulbs. See S. No. 289.

S. No. 286. (cf. S. No. 285). With respect to the place where they occur we may distinguish:
1a. subterranean bulbs. The large majority of bulbs belongs to this group. *Hyacinthus orientalis; Oxalis,* American and South-African species.
1. bulbils or aerial bulbs (bulbulus). They are relatively small bulbs arising in the axils of phyllomes or upon the phyllomes themselves, sometimes in the place of flowers. *Lilium bulbiferum; Allium vineale* and *Oxalis brasiliensis,* in the place of flowers.

S. No. 287. (cf. S. No. 285). A bulb is a cormoid organ existing during more than one and often during a considerable number of years; in the second and later years the older parts may remain, although they may have died and perform only an enveloping function. It is formed by a succession of cormoid parts which possess a caulome consisting of very short and relatively broad internodes and bear bulb-scales which during a period of their life, sometimes extending over several years, are thick and filled with reserve materials. These cormoid parts each correspond to a single vegetative period. With respect to the condition of ramification within the bulb we may distinguish:

1a. monopodial bulbs. Each successive part develops from a terminal bud, so that a series of annual shoots ensues belonging to one and the same cormus-individual. This construction of the main part of the bulb is only to be found in plants which develop their fructifications, eventually also their foliage cormi, from lateral buds, i.e. by branching and as separate cormus-individuals. *Galanthus nivalis; Leujocum vernum; Narcissus pseudonarcissus; Oxalis,* American species.

1b. sympodial bulbs. Each successive part develops from a lateral bud, so that a cormoid system ensues forming a sympodium. This mode of branching is only to be found in plants which develop their bulb exclusively from the cataphyllary region of a cormus-individual, while the middle region and at a certain age of the bulb the reproductive region of the same cormus-individual grow out into aerial parts, so that no vegetative cone remains which could produce a new bulb. The latter arises from a bud in the axil of one of the scales within the old bulb and thus a sympodium is formed composed of successive cormus-individuals. *Lilium Martagon; Fritillaria Imperialis; Oxalis,* South-African species.

1c. mono-sympodial bulbs. In a youthful stage the bulb is monopodial, but in a flowering condition it becomes sympodial. This mode of branching is to be found in plants which develop their bulb not only from the cataphyllary region, but also from the middle region, which forms a radical rosette, whilst at a later stage of the bulb a reproductive region of the same cormus-individual is developed, so that no vegetative cone remains for the formation of a bud. Then the new generation arises from a lateral bud and the bulb passes into the sympodial stage. *Hyacinthus orientalis.*

S. No. 288. (cf. S. No. 285). In the so-called dormant state of the bulb we may distinguish:

1a. the disc, stem or axis of the bulb (discus). This is composed of those parts of the caulome which exhibit extremely short internodes and belong to the successive annual shoots or cormus-individuals constituting the bulb. These parts correspond to the cataphyllary and middle regions of the several annual shoots or cormus-individuals and produce the thickened phyllomes which chiefly characterise the bulb. The older parts of the disc, corresponding to preceding vegetative periods, have a tendency to decay, like the basal parts of rhizomes.

1b. the bulb-scales. They are the thick phyllomes or parts of phyllomes which contain the reserve materials necessary for the yearly development of the aerial parts and roots from the bulb. They may be simply cataphylls, as in *Lilium* and *Fritillaria;* in many cases however there is only a restricted number of cataphylls either in the shape of an outermost sheath *(Galanthus nivalis; Gagea lutea)* or in the shape of scales *(Hyacinthus)*, whilst the major part is formed by the sheaths or broad bases of foliage leaves belonging to the aerial part of the preceding generation, as in *Hyacinthus* and *Galanthus* (the two inner scales of the bulb). The storage of reserve materials in the scales may take place at a very early period in that bud which is destined to produce aerial parts in the next year, as in the sheath formed in the bud of the bulb of *Gagea lutea,* but in general this storage is postponed to a later period and the scales are differentiated from parts of the fully developed foliage leaves or they are formed as cataphylls, anyhow belonging to an older period of the bulb, as in *Hyacinthus orientalis* and *Galanthus nivalis*. The number of bulb-scales formed by a part of the disc corresponding to a single annual shoot or cormus-individual may be very different: a single one in *Allium vineale,* two in *Fritillaria Meleagris,* three in *Galanthus nivalis,* sometimes many, as in *Hyacinthus orientalis* and *Lilium.* They may remain in function as stores of reserve material only during a single year *(Galanthus nivalis)*, but in other cases this function may be performed during a period of several years, so that the bulb is composed of thick and active scales belonging to successive periods, as in *Hyacinthus orientalis, Leucojum vernum, Muscari racemosus* and *botryoides.* When the reserve materials have been quite used up, the scales die off and mostly remain in a dry state investing the bulb, ofter during several years *(Allium Cepa; Tulipa; Gagea)*.

1c. the bud destined to form the aerial parts in the next vegetative period and slowly developing during the dormant state; these members will die off before the beginning of the next dormant period of the bulb; nevertheless, as has been said above, their basal parts may remain alive and contribute to the formation of bulb-scales *(Hyacinthus)*. Moreover remnants of the bases of the fructifications may often be found in a dried state between the dead scales investing the bulb *(Gagea lutea)* or between those still alive *(Hyacinthus)*.

1d. the bud of the bulb (gemma bulbi). In the dormant state of the bulb this bud is the part which will normally give rise to the annual shoot or cormus-individual destined to form the main part of the bulb in the next vegetative period, sometimes also to fructifications. In monopodial bulbs it is terminal *(Galanthus nivalis)*, in sympodial ones lateral *(Fritillaria)*, in mono-sympodial bulbs at first terminal, afterwards lateral *(Hyacinthus)*.

1e. bulbules or little bulbs (bulbulus). One or more lateral or adventitious buds, capable of producing new bulbs. In the ordinary course of development they often largely contribute to asexual reproduction, for instance in *Galanthus nivalis, Tulipa* and *Narcissus:* propagation by their means is more important than that by means of seeds; moreover in horticulture little bulbs are much used for the propagation of bulbs by means of scoring and scooping.

1f. fibrous roots (radix fibrosa). They begin their development during the dormant period of the bulb, growing from the base of the disc downwards; they may be branched. When the vegetative period is ended, they decay with the parts of the disc bearing them, to be replaced before the beginning of the next season by new ones from a younger part of the disc.

S. No. 289. (cf. S. No. 285). With respect to the character of their bulb-scales we may distinguish:
1a. tunicated bulbs (tunicatus). The majority of the outer scales wholly surrounds the bulb. *Allium Cepa; Galanthus nivalis.*
1b. naked bulbs (squamosus). Each scale surrounds only a part of the bulb. *Lilium candidum; Fritillaria Imperialis.*

S. No. 290. (cf. S. No. 191 and 273). Cormoid tubers (tuber). See for the meaning of this term S. No. 75. Concerning cormoid tubers the following subjects will be dealt with:
1a. subterranean and aerial cormoid tubers. See S. No. 291.
1b. tunicated and naked cormoid tubers. See S. No. 292.
1c. the general construction of tunicated tubers: sympodial and mono-sympodial tubers. See S. No. 293.
1d. the parts of the tunicated tuber. See S. No. 294.
1e. pseudobulbs. See S. No. 295.

S. No. 291. (cf. S. No. 290). With respect to the place where they occur we may distinguish:
1a. subterranean cormoid tubers. The large majority of cormoid tubers belongs to this group. *Solanum tuberosum,* ordinary tubers; *Colchicum autumnale.*
1b. aerial cormoid tubers (tuber caulinare). Examples of these are afforded by the so-called pseudobulbs of *Orchideae* (see S. No. 295) and by *Solanum tuberosum,* when small tubers are formed in the axils of foliage leaves.

S. No. 292. (cf. S. No. 290). With respect to the character of the phyllomes which they bear we may distinguish:
1a. tunicated cormoid tubers or corms of the older authors (tunicatus or bulbo-tuber). The outer scales wholly surround the tuber. *Crocus vernus, Colchicum autumnale, Arum maculatum.* See S. No. 294 and S. No. 295.
1b. naked tubers or simply tubers of the older authors (nudus). They are provided with numerous small scales, which may produce buds in their axils. *Solanum tuberosum, Helianthus tuberosus.*

S. No. 293. (cf. S. No. 290). In tunicated cormoid tubers we find more or less the same general construction as in bulbs, although less elaborately differentiated. They are also cormoid organs existing during more than one, generally during two periods of vegetation. Each of the parts corresponding to these periods is composed of a caulome exhibiting one or more, often somewhat elongated thick

internodes containing reserve materials and a certain number of thin phyllomes in the shape of dry investing scales, sometimes decayed already in the second year. With respect to the condition of ramification within these tubers we may distinguish:
1a. sympodial cormoid tubers. Each successive part develops from a lateral bud, so that a cormoid system ensues in the shape of a sympodium. This mode of branching is to be found in plants which develop their tuber from the cataphyllary region of a cormus-individual, whilst the middle region and at a certain age of the tuber the reproductive region of the same cormus-individual grow out into aerial parts, so that no vegetative cone remains which could produce a new tuber. The latter arises from a bud in the axil of one of the phyllomes (scales) of each tuber at the proper period and thus a sympodium is formed composed of successive cormus-individuals. *Colchicum autumnale; Malaxis.*
1b. mono-sympodial cormoid tubers. In a youthful stage the tuber is monopodial, but in a flowering condition it becomes sympodial. This mode of branching is to be found in plants, whose cormoid tubers develop in their youth a short middle region producing aerial foliage leaves, whilst no reproductive region is formed, so that a central vegetative cone remains able to produce a cormoid tuber for the next vegetative period. When however at a more mature age of the cormoid system a reproductive region with flowers appears the vegetative cone of the cormus-individual is lost and the cormoid tuber of a succeeding period can only be formed from a lateral bud, so that the monopodial construction existing at first is altered into a sympodial one. *Crocus vernus.*

S. No. 294. (cf. S. No. 290). In a tunicated cormoid tuber we may distinguish:
1a. the caulome part containing the reserve materials and forming the main part of the tuber. It may consist of a single internode *(Sturmia, Malaxis)*, but in general more internodes take part in its formation, although one of them may form the greater part of the tuber, as in *Colchicum autumnale* and *Crocus vernus*. The storage of the reserve materials in the caulome part takes place in the elder generation, whilst these materials are consumed by the younger one.
1b. the scales of the tuber. They are thin phyllomes investing the tuber, in some cases those of the elder generation surround both generations *(Colchicum autumnale; Crocus vernus*, more or less), but in other cases they soon decay, so that only the younger generation remains provided with them *(Arum maculatum)*.
1c. the bud destined to form the aerial parts in the next vegetative period and slowly developing during the dormant state; they die off before the beginning of the next dormant period of the tuber.
1d. the bud of the tuber. In the dormant state of the cormoid tuber this bud is the part which will normally give rise to a new generation destined to develop in the next vegetative period. In sym-

podial tubers it is lateral *(Colchicum autumnale)*, in monosympodial tubers it is at first terminal, afterwards lateral *(Crocus vernus)*.
1e. subordinate buds capable of producing new cormoid tubers. One or more lateral buds contributing to asexual reproduction. *Gladiolus communis.*
1f. fibrous roots (radix fibrosa). They grow from the base of the tuber, either from the elder generation while they are still wanting in the younger *(Crocus vernus)*, or from the younger one while those of the elder generation have decayed *(Arum maculatum)*.

S. No. 295. (cf. S. No. 290). The so-called pseudobulbs (pseudobulbus) of *Orchideae.* They occur in several modifications:
1a. they are the elongated cataphyllary regions of certain cormus-individuals consisting of several internodes; they produce leaf-scales of moderate dimensions, enveloping only a part of each internode; a middle region with foliage leaves may be produced at the top. *Epidendron ciliare; Dendrobium densiflorum.*
1b. they are the cataphyllary regions of certain cormus-individuals, in their youth wholly enveloped by leaf-scales, whilst chiefly a single one of their internodes forms the tuber; a middle region with foliage leaves may be produced at the top. *Coelogyne cristata; Laelia anceps.*
1c. they are the middle regions of certain cormus-individuals producing foliage leaves whose sheaths at first envelop the tuber, whilst they are thrown off afterwards; these pseudobulbs consist of one or more thickened internodes. *Lycaste aromatica; Phajus grandifolius.*

S. No. 296. (cf. S. No. 273). Concerning cormoid fructifications the following subjects will be dealt with:
1a. stolons or runners. See S. No. 297.
1b. cormoid receptacles. See S. No. 298.
1c. strobili. See S. No. 299.
1d. floral cormi. See S. No. 300.

S. No. 297. (cf. S. No. 296). Stolons or runners (stolon, sarmentum). These terms designate lateral cormus-individuals, mostly basal branches, performing the function of vegetative reproduction. They are fructifications, producing as their primary reproductive organs buds or tubers which ultimately grow out into new plants; they are more or less elongated and grow in a more or less horizontal direction, sometimes hanging down; they are mostly provided with leaf-scales and roots and produce their primary reproductive organs, either at their ends or in the axils of bud-scales at their nodes. We may distinguish:
1a. surface stolons, surface runners or flagella. They develop in the air and are often filiform and very long. *Mniaceae* [1]; *Catharinea; Hieracium Pilosella; Fragaria vesca; Saxifraga*

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[1] Rabenhorst's Kryptogamen-Flora, IV, Limpricht, Laubmoose, 2, Leipzig 1895, p. 448.

sarmentosa; Chlorophytum Sternbergianum; Potentilla Anserina; Epilobium montanum, short stolons.

A special kind of these is called:

2a. inflorescence runners. *Potentilla tormentilla* (the sympodial axis of the cincinnus acting as runner).

Analogous to cormoid runners are:

2b. leaf-runners. They are elongated, cylindrical outgrowths of Fern-leaves producing no leaflets, but at their ends buds and roots, which produce new plants. *Camptosorus rhizophyllus* or *Walking Fern; Asplenium obtusifolium* and *Manii,* here the first leaf of the bud in its turn forms a leaf-runner, so that a sympodium of runners results.

1b. submerged runners. *Hydrocharis Morsus-ranae.*

1c. subterranean or underground stolons, runners or offsets. *Solanum tuberosum* and *Helianthus tuberosus,* branched runners from the ends of which the tubers develop; *Valeriana officinalis,* offsets of the rhizome; *Struthiopteris germanica* and *Osmunda regalis* [1]).

S. No. 298. (cf. S. No. 296). Cormoid receptacles. This term designates fructifications formed by the apical part of a cormus-individual comprising only two of its regions, namely:

1a. the perichaetium corresponding to the region of enveloping phyllomes (cf S. No. 247). Its members exhibit a somewhat metamorphosed differentiation from the foliage leaves which may be placed below them on the same cormus-individual.

1b. the region of gemmae (asexual reproduction)or gametangia (cf. S. No. 248) ; the latter often combined with paraphyses.

These fructifications are cup-shaped, disciform or more bud-shaped, while the lower regions of the cormus-individual to which they belong may be either well-developed or more or less reduced, often wanting [2]).

Examples: *Tetraphis pellucida,* gemma-cups (upper parts of more complete cormus-individuals) ; *Polytrichum commune* (dioecious, upper parts of more complete cormus-individuals) ; *Hypnum intermedium* and other pleurocarpous *Musci* (upper parts of reduced cormus-individuals).

See moreover p. 30.

S. No. 299. (cf. S. No. 296). Strobili. This term designates fructifications formed by a specialized cormus-individual with limited growth, or by the specialized apical part of a cormus-individual with limited growth. In the strobilus the middle region is never present, but it comprises one or two other regions, namely:

1a. the region of enveloping phyllomes, which may be more or less developed, but in other cases may be wanting. Its members exhibit a differentiation metamorphosed from that of the foliage leaves, which may be placed below them on the same cormus-individual. The lower region of the cormus-individual to which this fructification belongs may be either well-developed or more or less reduced or even wanting.

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[1]) Goebel. Outlines of classification. Oxford 1887, p. 209.

[2]) Rabenhorst's Kryptogamen-Flora IV, 2, p. 645 sq.

1b. the region of the sporophylls (cf. S. No. 233). The sporophylls may be intermixed with sterile bracts *(Calamostachys; Cycadoidea ingens,* megasporophylls intermixed with interseminal scales); but usually the region only exhibits sporophylls. If there are mega- and microsporophylls these two occupy separate parts of the caulome. In such cases the microsporophylls collectively form the androecium of the strobilus and may be developed in the shape of stamens (see S. No. 333), the megasporophylls collectively form the gynoecium of the strobilus, but they never develop into a pistil.

Examples: *Equisetum arvense* (isosporophylls, enveloping phyllomes as a so-called annulus); *Pinus silvestris,* male inflorescence (stamens and enveloping phyllomes).

With respect to the distribution of androecium and gynoecium we may distinguish the following cases:

2a. microsporophylls in the middle, megasporophylls in the apical part of the strobilus. *Cycadoidea ingens.*

2b. megasporophylls in the middle, microsporophylls in the apical part of the strobilus. *Lepidostrobus Veltheimianus.*

2c. microsporophylls at the upper side of the horizontally placed strobilus, megasporophylls at the under side. *Selaginella* spp. with horizontal strobilus.

For stamens belonging to a strobilus see S. No. 333.

For ovules belonging to a strobilus see S. No. 353, 1b, 1i, 1k.

For the difference between a strobilus and a flower see S. No. 300.

In the female fructifications of several Gymnospermae the developmental characters of the megasporophylls are much obscured by reduction, so that in several cases there are controversies connected with the nature of the fructification and its parts.

In the *Pinaceae* the place of megasporophylls is taken by two kinds of scales, called bract scale or tegumentary scale and ovuliferous or seminiferous scale. The ovuliferous scale is placed in the axil of the bract scale, it bears the ovules and may afterwards assume a woody character *(Pinus);* the two scales may coalesce more or less *(Taxodiaceae).* The ovuliferous scale is considered by some authors as a ligular or placental outgrowth ¹), by others as a slightly developed branch producing two coherent sporophylls ²). According to the first view the fructification should be taken as a strobilus, according to the second view as an inflorescence or compound strobilus.

S. No. 300. (cf. S. No. 296). Floral cormi. The term floral cor-

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¹) A. W. Eichler, Ueber die weiblichen Blüthen der Coniferen. Monatsber. K. Akad. d. Wiss. Berlin 1881. S. 1020.

²) Velenovsky, Vergl. Morphologie d. Pflanzen III. Prag. 1910. S. 757.

mus or simply flower is used for higher developed strobili; especially the strobilus of the Angiospermae always has been designated by this term. Amongst Gymnospermae both the terms strobilus and flower are in use, the term flower with predelection in such cases where the androecium occupies the middle part, the gynoecium the apical part of the caulome *(Cycadoidea, Welwitschia* female fructification) or in cases where the phyllomes of the fructification are of limited number and occur in connate whorls *(Gnetales)*, less in unisexual fructifications with a great number of spirally arranged phyllomes *(Cycadales)*. Yet in the latter cases the term flower may be used equally well, and some authors even extend the use of this to the fructifications of some Pteridophyta *(Equisetum)*.

Recognizing therefore fully that the distinction between strobilus and flower is by no means a sharp one, the flower is characterized by its perianth, which may be very simple or even wanting, but which often shows a high degree of specialisation, by its microsporophylls, which have the shape of stamens, by its megasporophylls, which in Angiospermae have the shape of pistils or which are coalesced into a single pistil, by the strict order of sequence of perianth, androecium and gynoecium, by the tendency to reduction of the number of phyllomes in each zone and by the tendency to whorled phyllotaxy.

The existence of the flower gives rise to the formation of other fructifications in two somewhat opposite directions.

On the one hand there is a tendency of flowers to combine into more or less complicated groups which appear as independent fructifications and in this respect it is important to consider the various conditions in which the more basal part of a cormus-individual producing a flower at its top may appear. In the first place there are cases in which the flower is placed at the top of a fully differentiated cormus-individual with a normal cataphyllary region (cf. S. No. 244) and a middle region bearing foliage leaves; in this case a bracteal region is wanting and the transition between the vegetative and the reproductive regions is formed by a single internode between the insertion of the highest foliage leaf and that of the perianth, so that there exists a more or less elongated flower-stalk for which no special term is in use, although it may be considered as constituting together with the flower a somewhat extended fructification; examples of this kind are afforded by *Papaver somniferum, Paris quadrifolia* and *Tulipa*. Such cases however are by no means very numerous, for in the majority of flowering plants the cormus-individual to which the flower belongs has a reduced vegetative region not exhibiting foliage leaves; it has been differentiated into a more extended fructification consisting not only of a flower, but also of the more basal parts of the cormus-individual often bearing cataphylls. In very many cases again a similar fructificative differentiation has taken place in neighbouring cormus-individuals, so that clusters of flowers (inflorescences) ensue, corresponding to cormoid systems which may be haplocaulescent, but which may be in many cases diplo- up to pleiocaulescent, whilst only the ultimate branches produce a flower at their tops. In such cases it often occurs that the basal parts of the cormus-individuals which bear the flowers are so much reduced that they seem to have disappeared altogether.

On the other hand the central female part of the flower, after fertilisation has taken place, has a tendency to remain till after the flowering period and to assume a peculiar, often highly developed specialization and then to appear as a somewhat independent organ called fruit and containing seeds.

Thus concerning floral cormi the following subjects will be dealt with:
1a. anthotaxy and inflorescence. See S. No. 301.
1b. the flower. See S. No. 317.
1c. the fruit. See S. No. 381.

S. No. 301. Anthotaxy (anthotaxis) and inflorescence (inflorescentia) (cf. S. No. 300). Concerning anthotaxy and inflorescence the following subjects will be dealt with:
1a. anthotaxy, definition of the term. See S. No. 302.
1b. kinds of anthotaxy. See S. No. 303.
1c. inflorescence. See S. No. 304.

S. No. 302. (cf. S. No. 301). Anthotaxy (anthotaxis). This term designates in a general way the disposition and mutual arrangement of the flowers (in a few cases strobili) produced by a single plant-individual.

S. No. 303. (cf. S. No. 301). In anthotaxy we may distinguish the following cases:
1a. the one-flowered plant (planta uniflora). As a rule there is only a single flower on each plant-individual. *Crocus vernus; Galanthus nivalis; Iris pumila* and *reticulata.*
1b. terminal flowers in cormus-individuals exhibiting also foliage leaves and cataphylls. *Papaver somniferum; Paris quadrifolia; Tulipa sylvestris.*
1c. scattered or solitary flowers (flores sparsi). Each plant-individual produces more than one flower, but the floral cormi have no middle region, and each of them arises from the axil of an ordinary foliage leaf. *Tropaeolum majus; Convolvulus Sepium; Callitriche stagnalis; Salsola Kali; Glaux maritima.*
1d. the inflorescence (inflorescentia). This term designates a cormoid system bearing more than one and often a very large number of flowers between which however no ordinary foliage leaves do appear. See S. No. 304.
1e. cauliflory. This term designates the production of flowers or inflorescences from the main stem or older woody branches of trees; in many cases these flowers and inflorescences arise from dormant axillary buds. *Theobroma cacao; Cercis siliquastrum.*

S. No. 304. (cf. S. No. 301). Inflorescence. Concerning the inflorescence the following subjects will be dealt with:
1a. disposition. See S. No. 305.
1b. the parts constituting inflorescences. See S. No. 306.
1c. special kinds of inflorescences. See S. No. 307.

S. No. 305. (cf. S. No. 304). With respect to disposition, without taking into account their own mode of ramification, we may distinguish:
1a. terminal inflorescences. They are placed at the top of a cormus-individual which exhibits also a middle region. *Aloinae, Metroxylon, Fourcroya, Digitalis purpurea* and *Helianthus annuus* in their main stem and larger branches; *Musa; Zea Mays,* male inflorescence; *Orchideae acranthae; Vanilla, Epipactis; Fragaria vesca; Rubus Idaeus; Cruciferae.*
1b. lateral inflorescences. They are produced by cormus-individuals exhibiting no middle region. *Oxalideae; Phoenix dactylifera; Vicia Sepium; Zea Mays,* female inflorescences; *Ravenala; Orchideae pleuranthae: Phajus.*

S. No. 306. (cf. S. No. 304). In describing solitary flowers and inflorescences the following terms are used:
1a. the sessile flower (flos sessilis). This term designates the condition of a flower when the basal parts of the floral cormus below the perianth are developed in so slight a measure that the flower cannot be said to possess a stalk. *Callitriche stagnalis; Salsola Kali; Glaux maritima; Acorus Calamus; Gunnera scabra; Gramineae.*
1b. the pedicel (pedicellus). This term designates the special and relatively small stalk of a single flower. This stalk always belongs to the floral cormus. It may represent the whole floral cormus below the perianth, on condition that this part is unbranched and bears at most only a few sterile cataphylls. If the floral cormus exhibits a basal part which produces cataphylls from whose axils branches arise, the part below the cataphylls is not considered as belonging to the pedicel, but is called peduncle. *Tropaeolum majus; Convolvulus sepium; Ribes rubrum; Primula obconica; Fragaria vesca,* where the basal part of the floral cormus is a peduncle, producing branches.

See moreover M. N. No. 22.
1c. the peduncle (pedunculus). This term designates all caulomes belonging to the bracteal region which are not pedicels. They may be branched, thus representing cormoid systems, and in this case we may distinguish a primary or general peduncle, (pedunculus communis) and branches of the first, second, etc. order. The branches of the cormoid systems are often essential cormus-individuals, so that the whole system is pleiocaulescent (botryose inflorescences, see S. No. 311), but in other cases the cormoid system is haplocaulescent (cymose inflorescences, see S. No. 311) and then

a part of each cormus-individual may be differentiated into a pedicel, as has been mentioned under 1b.

See moreover M. N. No. 22.

1d. the scape (scapus). This term designates a long stalk mostly arising from beneath or near the surface of the ground, often from a radical rosette; in the majority of cases it bears an inflorescence; it mostly consists of a single internode only. *Taraxacum officinale; Himantophyllum; Hyacinthus; Richardia aethiopica; Butomus umbellatus; Gladiolus; Anthurium; Heracleum giganteum; Curcuma longa* (consisting of several internodes and having scale-leaves). A single flower is borne e.g. by the scapes of *Narcissus poeticus; Galanthus nivalis.*

1e. terms used for phyllomes of the bracteal region.

2a. the spathe (spatha). This is a single large bracteal phyllome enveloping a whole inflorescence or its principal branches, although not being their subtending phyllome (cf. S. No. 246). *Aroideae, Palmae.*

In some cases the term is used to designate a bracteal phyllome enveloping only a single flower. *Narcissus poeticus, Galanthus nivalis, Iris pseudacorus.*

3a. spathilla (spathilla). This term designates diminutive spathes in the shape of stemclasping bracts inserted at the base of the branches in spathe-bearing inflorescences. *Raphia Ruffia Mart*[1]).

2b. bracts (bractea). This is a somewhat comprehensive term for designating phyllomes of the bracteal or hypsophyllary region and is especially used for the subtending phyllomes of the peduncles and of the pedicels.

3a. the involucre (involucrum). This term designates a group of several, often very numerous, bracts with short internodes between them, surrounding an inflorescence, so that they more or less seem to stand in the same transverse plane. *Dipsacus silvestris; Taraxacum officinale* (at the top of a scape); *Armeria maritima.* If involucres occur both at the base of ramifications of the first order, and at that of the second order, (*Daucus carota*) the terms universal and partial involucre (the latter also called involucellum) are used. See S. No. 313. In some cases this term is used also for a group of bracts surrounding a single flower. *Eranthis hyemalis, Althaea rosea.* It is probable that the members of such an involucre must be considered as bracts in whose axils the flowers have not been developed.

3b. the glumes (gluma). This term designates scaly chaff-like bracts representing the prophylls of certain spikelets which they envelop more or less completely. *Gramineae: Lolium perenne, Alopecurus pratensis, Poa annua.*

3c. the paleae, chaffs, palets or pales (palea). See S. No. 313. This term designates moreover two scaly chaff-like phyllomes enveloping the flowers of the Gramineae. The outer one, the palea inferior represents the subtending bract of the flower. See moreover sub 1e, 2c.

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[1]) Eichler. Blüthendiagramme I, p. 107.

3d. the utricle (urceolus). This term designates a sac arising by means of concrescence from a single bract surrounding a female flower. *Carex.*

2c. bracteoles[1] (bracteola). They correspond to the cataphyllary region of a cormus-individual, without middle region, forming a flower at its top and they may be either inserted on a pedicel, in which case they never subtend other cormus-individuals (simple botryose inflorescences), or they belong to the peduncular part of a floral cormus and in this case they subtend floral cormi, so that from this point of view they may be considered as bracts (cymose inflorescences); there may be one *(Monocotylae)* or two *(Dicotylae)* and in the latter case, if there is a difference of age the older one is called α, the younger β (cf. S. No. 268).

The term paleae is used for the scaly chaff-like bracteal phyllomes enveloping the flowers of *Gramineae,* the higher one of these (palea superior) corresponds to a bracteole.

1f. partial or special inflorescence. This term is only used in cases of complicated fructifications, where different kinds of ramification have been combined together. The peripheral ramifications may then represent complete inflorescences of a more simple kind and these are designated by the term partial or special inflorescence. Many examples are afforded by mixed botryose inflorescences (see S. No. 313) and by heterotactical inflorescences (see S. No. 315).

S. No. 307. (cf. S. No. 304). Special kinds of inflorescences. The general structure of inflorescences is often very complicated and not seldom difficult to unravel, but four kinds of characters, although of very different importance, may serve as bases for distinguishing special kinds of inflorescences. They are:

1a. the deciduous (cf. S. No. 13) character of the inflorescence. See S. No. 308.

1b. the more or less succulent consistency of the peduncle. See S. No. 309.

1c. the mode of ramification. See S. No. 310.

1d. the general shape, without taking into account the mode of ramification. See S. No. 316.

S. No. 308. (cf. S. No. 307). The deciduous character of some inflorescences has given rise to the term catkin (amentum). This term designates inflorescences, when the male ones are thrown off as a whole at the end of the flowering period and the female after the fruits have ripened. The male catkins exhibit various kinds of ramification, they are often elongated and pendulous. *Salix alba; Juglans regia; Alnus glutinosa; Betula alba.* See S. No. 313 and S. No. 315.

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[1] The following terms have been used sometimes, but were not generally adopted: 1. bracts (bractea) for the subtending phyllomes of the branches of the peduncle; 2. bracteoles (bracteola) for the subtending phyllomes of the pedicels; 3. bracteolules (bracteolula) for the phyllomes of pedicels. Oudemans en de Vries, Leerboek der Plantenkunde. Vol II, 1. Oudemans Vormleer, 2. ed. Nijmegen 1895, p. 138.

S. No. 309. (cf. S. No. 307). The more or less succulent condition of the peduncle has given rise to the following terms:
1a. the spadix (spadix). This term designates an inflorescence exhibiting a succulent, more or less cylindrical or club-shaped unbranched or branched peduncle, while there is sometimes, as in the female spadix of *Zea Mays,* a tendency of the flowers and fruits to be somewhat sunk into the succulent substance. *Richardia aethiopica* and *Acorus Calamus*; *Typha* and *Sparganium*; *Ananas sativus*; the inflorescence of all *Palmae* is commonly called a spadix, although in many cases the peduncle is woody.
1b. the coenanthium[1]) (coenanthium). This term designates an inflorescence exhibiting a succulent peduncle which has the shape, either of a disc bearing flowers on its upper side, or that of a cup bearing flowers on its inside. *Dorstenia* and *Antiaris; Ficus.*

S. No. 310. (cf. S. No. 307). With respect to the mode of ramification the following subjects will be dealt with:
1a. difference between botryose and cymose inflorescences. See S. No. 311.
1b. homotactical and heterotactical inflorescences. See S. No. 312.
1c. botryose inflorescences. See S. No. 313.
1d. cymose inflorescences. See S. No. 314.
1e. heterotactical inflorescences. See S. No. 315.

S. No. 311. (cf. S. No. 310). With respect to the mode of ramification we may distinguish:
1a. botryose, racemose, botryoidal, centripetal, indefinite or indeterminate inflorescences (racemosus, botryosus, botryoides). In addition to the general characters of the botryose type of ramification mentioned in S. No. 59 we may state that the top of the primary peduncle in most cases does not produce a flower (exceptions for instance *Berberis, Prunus laurocerasus)* and that the development of the lateral flowers generally proceeds in the order of their age from the lower or outer ones towards the top or centre. Moreover[2]) botryose inflorescences are composed of at least two kinds of essential cormus-individuals, so that they may be called pleiocaulescent cormoid systems; in the most simple cases their essential cormus-individuals are represented by the primary peduncle and the floral cormi; but in many cases the peduncle is branched, even profusely and this may give rise to the

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[1]) This term has been sometimes used for the general peduncle or receptacle of a head, but this is not advisable. Asa Gray Bot. textbook, vol. I, New York 1879, Glossary.

[2]) Eichler. Blüthendiagramme I p. 33.

formation of additional essential cormus-individuals as the branches of successive orders. See S. No. 313.
1b. cymose, centrifugal, definite or determinate inflorescences (cymosus). In addition to the general characters of the cymose type of ramification mentioned in S. No. 59 we we may state, that the top of the primary peduncle produces in the great majority of cases a flower and that the development of the flowers generally follows the order of the successive generations of cormus-individuals, so that the central or top flower opens first, followed by the lateral flowers of successive higher orders, i.e. in a more or less centrifugal way.

Moreover cymose inflorescences are composed only of a single kind of essential cormus-individual, so that they may be called haplocaulescent cormoid systems; their cormus-individuals are branches producing a flower at their top, often borne by a well-differentiated pedicel, whilst their lower peduncular part possesses a cataphyllary region often of one or two, in a few cases a larger number of phyllomes and from the axils of these there may arise branches of the same kind which in their turn exhibit the same phenomena. See S. No. 314.

S. No. 312. (cf. S. No. 310). With respect to the occurrence of botryose and cymose ramification we may distinguish:
1a. homotactical inflorescences. All ramifications occurring in the inflorescence are either botryose or cymose. Examples are to be found in S. No. 313 and S. No. 314.
1b. heterotactical inflorescences. Botryose and cymose ramifications both occur in one and the same inflorescence. See S. No. 315.

S. No. 313. (cf. S. No. 310). Botryose inflorescences. Here we may distinguish:
1a. simple botryose inflorescences. Peduncle unbranched.

2a. the raceme (racemus or botrys). Peduncle elongated, pedicels well-developed. *Ribes rubrum*; *Prunus Padus*; *Laburnum anagyroides (Cytisus Laburnum); Capsella Bursa-pastoris; Menyanthes trifoliata.*

3a. the simple corymb (corymbus simplex). This term is used for a raceme when the lower pedicels are so much longer than the higher, that all flowers are placed almost in the same transverse plane. *Ornithogalum umbellatum; Pyrus communis.*

2b. the spike (spica). Peduncle elongated, pedicels shortened. *Plantago major; Orobanche; Orchis maculata; Podocarpus spicata* (spikes of male strobili cf. S. No. 299).

The term spikelets (spicula) is used for designating relatively small spikes, taking part, as partial inflorescences, in the formation of more complicated inflorescences, independent of other modes of ramification which may appear in the latter.

In connection with the succulent character of the peduncle and the deciduous character of the whole inflorescence we may distinguish the following modifications of the spike:

3a. the simple spike metamorphosed into a spadix (cf. S. No. 309). *Richardia aethiopica; Calla palustris; Typha latifolia; Ananas sativus*; *Palmae*: *Chamaedorea pauciflora*, female inflorescence [1]), *Geonoma pycnostachys*.

3b. the simple spike metamorphosed into a catkin (cf. S. No. 308). *Salix alba; Juglans regia.* See also S. No. 315.

2c. the umbel (umbella). Peduncle shortened, pedicels elongated; the umbel mostly appears at the top of a scape. *Trifolium pratense* (umbella globosa).

3a. the superposed umbels (umbellae superpositae). The scape at whose top an umbel arises continues its growth in length and the formation of umbels at its top is reiterated, so that several umbels appear at more or less regular distances from one another. *Hottonia palustris; Primula imperialis.*

2d. the head (capitulum). Peduncle and pedicels shortened. The peduncle of a head is sometimes called common receptacle of the inflorescence (receptaculum commune). Confer moreover p. 30. Many heads are provided with an involucre (cf. S. No. 306) and in this case the bracts subtending the flowers are called paleae, chaffs, palets or pales (palea), while the term florets is often used for the flowers. With respect to the character of the flowers we may distinguish:

3a. homogamous flower-heads. There is only a single kind of flower.

3b. heterogamous flower-heads. There are two kinds of flowers.

4a. disc-florets. Those occupying the centre of the head.

4b. ray-florets. Those at the periphery surrounding the disc-florets.

Examples are afforded by: *Jasione montana,* homogamous and without involucre; many *Compositae: Carduus* and *Cirsium,* homogamous with involucre and paleae; *Eupatorium cannabinum* and *Taraxacum officinale,* homogamous with involucre and without paleae; *Aster, Calendula vulgaris, Bellis, Centaurea Cyanus,* heterogamous; *Cephalotaxus Fortunei* (heads of male strobili cf. S. No. 299).

1b. compound botryose inflorescences. Peduncle branched.

2a. uniformly reiterating botryose inflorescences. In the least complicated cases there appear, instead of the flowers of a simple inflorescence, branches of the peduncle of the first order only, whilst those branches are either elongated or shortened, just as the primary peduncle. Inflorescences of this kind may be termed unicompound or compound sans phrase. In other cases however the peduncle may bear branches of higher orders and then we may use the terms bicompound, tricompound up to pluricompound.

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[1]) Martius. Historia Naturalis Palmarum, 1831—1850, München, vol. II, tab. 3 and tab. 17.

3a. the compound raceme (racemus compositus). This term designates a compound, bi-, tri-, up to pluricompound raceme with racemules (racemuli) as ultimate inflorescences. *Hydrangea Hortensia, Syringa vulgaris, Liguster, Fraxinus excelsior, Bromelia.*

3b. the compound spike (spica composita). This term designates a compound, bi-, tri-, up to pluricompound spike producing spikelets as ultimate inflorescences. *Lolium perenne* and *Agropyrum (Triticum) repens* (unicompound).

4a. the compound spike metamorphosed into a spadix (cf. S. No. 309). *Gunnera scabra* (unicompound); *Zea Mays,* female inflorescence (unicompound); *Palmae: Phoenix dactylifera* (unicompound), *Oenocarpus Bataua* [1] (unicompound), *Euterpe edulis* [2] (unicompound), *Geonoma multiflora* [3] (bicompound), *Leopoldinia pulchra* [4] (tricompound).

3c. the compound umbel (umbella composita). This term designates a compound umbel of which the ultimate inflorescences are called umbellules or partial umbels (umbellula), whilst the primary umbel is sometimes called universal (universalis). Universal and partial involucres may occur (cf. S. No. 304). Many *Umbelliferae,* for instance *Daucus carota, Foeniculum officinale.*

3d. the compound head (capitulum compositum). This term designates a compound head of which the ultimate inflorescences are each represented by a single flower which however is surrounded by an involucellum. *Echinops, Vernonia.*

2b. mixed botryose inflorescences. They are formed by a combination of two or more different botryose inflorescences. These combinations have not given rise to special terms, but are characterised by means of a short description. Examples are afforded by: *Hedera Helix,* raceme with umbels as partial inflorescences; *Inula Conyza* and *Lappa tomentosa,* simple corymb with heads as partial inflorescences; *Petasites officinalis,* raceme with heads as partial inflorescences; *Poa pratensis* and *Avena sativa,* compound racemes with spikelets as partial inflorescences; *Digitaria,* umbel of compound spikes having spikelets as partial inflorescences.

S. No. 314. (cf. S. No. 310). Cymose inflorescences. With respect to the number of cataphyllary phyllomes produced by each of the cormus-individuals which constitute a cymose inflorescence we may distinguish:

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[1] Martius, l.c. vol. II, tab. 27.
[2] Martius, l.c. vol. I, tab. ZX and vol. II, tab. 32.
[3] Martius, l.c. vol. II, tab. 5 and 6.
[4] Martius, l.c. vol. II, tab. 53.

1a. the pleiochasium (pleiochasium). The number of cataphylls is more than two.

2a. the trichasium (trichasium). There are three cataphylls. The genus *Eriogonum* [1]) *(Polygonaceae)*.

2b. the cyathium (cyathium). There are five cataphylls, forming an involucre surrounding a female central apical flower and producing in their axils cincinni of male flowers. *Euphorbiaceae: Euphorbia Helioscopia.*

1b. the dichasium (dichasium). There are two branches beneath each apical flower arising from the axils of bracteoles α and β, although in a few cases one or more additional sterile cataphylls may occur. If however these additional cataphylls produce flowers from their axils the inflorescence becomes botryose *(Phlox; Pentstemon* [2])). The two branches of the dichasium may be either homodromous or antidromous with respect to the podium, but it is a very general rule that they are in this respect different from one another, so that when the branch arising from bracteole α is either homodromous or antidromous, that arising from β is either antidromous or homodromous. The grade of development of both branches may be the same, but in most cases there is a hereditary tendency of one of the branches to become stronger, so that the branch arising from bracteole α or β exhibits either a furthered or a repressed development. This repressed development may lead to abortion and thus to the formation of a monochasium, a phenomenon which many dichasia display in their last formed feeble branches. Thus dichasia may either show a screw-tendency or o cincinnus-tendency [3]). *Cerastium triviale,* cicinnus-tendency; *Nerium Oleander,* screw-tendency.

1a. the monochasium (monochasium). There is only a single branch below each top-flower, so that in all cases there is a tendency to form a sympodium which often becomes straight after the flowering period (post anthesin) and fully developed if sufficient longitudinal extension takes place. For the rest the origin of the single branch may be the consequence either of the fact that there is only a single bracteole from whose axil a branch can spring or, if there are two bracteoles α and β, only one of them is fertile and produces a branch from its axil, while the other remains sterile. Here we may distinguish:

2a. the sickle or drepanium (drepanium). (cf. S. No. 62). *Juncaceae,* partial inflorescences.

2b. the fan or rhipidium (rhipidium). (cf. S. No. 62). Some *Irideae,* for instance *Iris pseudacorus,* partial inflorescences.

2c. the screw or bostryx (bostrychus, bostryx). (cf. S.

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[1]) Velenovsky, l.c. p. 819.

[2]) Eichler. Blüthendiagramme, I p. 34.

[3]) Wydler, Ueber die symmetrische Verzweigungsweise dichotomer Inflorescenzen. Flora, 34, 1851, p. 289 ss. When reading this important paper it ought to be kept in mind that the terms emprosthodromous and opisthodromous were used by the author in the same sense in which they were used by Braun and Schimper, but an opposite meaning was given to them afterwards by Eichler and all recent authors. Confer S. No. 271.

No. 62). In addition to the general characters mentioned in S. No. 62 we may state: 1. that the flowers of all branches are respectively homodromous with those of their successive podia; 2. that the flowers may be either emprosthodromous or opisthodromous. Thus the following cases become possible:

3a. the branch belongs to bracteole α which may also be the only one present.

4a. flowers emprosthodromous. *Asclepiadeae*; *Apocynaceae*; dichasia with screw-tendency in their feebler branches.

4b. flowers opisthodromous. No examples have come to my notice.

3b. the branches belong to bracteole β.

4a. flowers emprosthodromous. *Hypericum.*

4b. flowers opisthodromous. No examples have come to my notice.

2d. the cincinnus (cincinnus, cicinnus). (cf. S. No. 62). In addition to the general characters mentioned in S. No. 62 we may state: 1. that the flowers of all branches are respectively antidromous to those of their successive podia; 2. that the flowers are either emprosthodromous or opisthodromous. Thus the following cases may become possible:

3a. the branch belongs to bracteole α which may also be the only one present.

4a. flowers emprosthodromous. *Tribulus; Erythraea.*

4b. flowers opisthodromous. Many *Ranunculaceae.*

3b. the branches belong to bracteole β.

4a. flowers emprosthodromous. This is by far the most common case, as may be proved by the following list of examples, which also contains cases of dichasia with cincinnus-tendency: *Malvaceae, Saxifragaceae, Valerianaceae, Boragineae, Hydrophyllaceae, Solanaceae, Nolanaceae, Scrophulariaceae, Labiatae, Polygonaceae, Drosera, Corrigiola* and *Herniaria, Amaranthus, Linum, Oxalis, Aesculus, Dictamnus, Ruta, Staphylea, Rubus, Comarum, Fragaria.*

4b. flowers opisthodromous. *Aizoon.*

The cincinnus being a very commonly occurring inflorescence, which may be easily confounded with a raceme, it seems advisable to mention here as prominent characters for recognising it: 1. the apical part is mostly rolled up; 2. the flowers are distributed along the sympodial axis alternately in two longitudinal rows, at the convex side of the sympodial axis, their planes being at right angles to one another; 3. the fertile bracts, if occurring, are placed along the sympodial axis, each opposite to a flower and thus they are also arranged in two rows, whilst the sterile bracts, if occurring are placed at the base of or on the pedicels.

S. No. 315. (cf. S. No. 310). Heterotactical inflorescences. There exist many kinds of these inflorescences, but no special terms are in use for them. Hence it will suffice to enumerate a certain number of examples here[1]: *Aesculus Hippocastanum:* compound raceme with cincinni as partial inflorescences; *Chelidonium majus*: screw with umbels (strongly shortened racemes) as partial inflorescences; *Betula alba* and *Alnus glutinosa,* male inflorescences: simple spike metamorphosed into a catkin with three-flowered dichasia as partial inflorescences; *Cichorum Intybus* and *Endivia:* screw with heads as partial inflorescences; *Caucalis nodiflora:* screw with umbels as partial inflorescences; *Armeria:* head with cincinni as partial inflorescences; *Haemanthus* and *Alstroemeria:* umbels with screws as partial inflorescences; *Allium spp.:* head with screws as partial inflorescences; *Juncus spp.:* sickle with heads as partial inflorescences.

S. No. 316. (cf. S. No. 307). With respect to the general shape we may distinguish:

1a. the panicle (panicula). This term designates a cluster of flowers exhibiting a more or less pyramidal shape, in consequence of the relations in length between the lower lateral axes and those more towards the apex. *Syringa vulgaris; Aesculus Hippocastanum; Poa annua.*

1b. the corymb (corymbus). This term designates a cluster of flowers which is flat-topped or convex, in consequence of the relations in length between the lower lateral axes, the higher ones and the apex itself. *Sambucus nigra*; *Achillea millefolium*; *Spiraea Ulmaria*; *Hydrangea Hortensia.*

1c. the anthela (anthela). This term designates a cluster of flowers exhibiting a more or less concave shape, the basal lateral axes overtopping the more central ones and the apex. All *Juncaceae,* for instance *Juncus* and *Luzula.*

1d. the glomerule (glomerula). This term designates a cluster of flowers condensed into the form of a head or approaching it. *Cornus florida* and *Canadensis; Echinops.*

1e. the false whorl (verticillaster). This term designates an apparent whorl of flowers surrounding the caulome, actually however composed of two cymose inflorescences, one on each side of the same node. *Labiatae: Lamium album.*

S. No. 317. Flower. (cf. S. No. 300). Concerning the term flower the following subjects will be dealt with:

1a. meaning of the term. See S. No. 318.
1b. parts composing the flower. See S. No. 319.
1c. parts of doubtful nature. See S. No. 320.
1d. the floral receptacle. See S. No. 321.
1e. the perianth: calyx, corolla, and perigon. See S. No. 325.
1f. the androecium. See S. No. 333.
1g. the gynoecium. See S. No. 353.
1h. special kinds of flowers. See S. No. 375.

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[1] Oudemans en de Vries. Leerboek der Plantkunde, vol. I, Oudemans, Vormleer, 2. ed., Nijmegen 1895, p. 143, 145, 149 and 150.

S. No. 318. (cf. S. No. 317). Meaning of the term flower. As has been set forth in S. No. 300 this term designates the highly specialized apical part with limited growth of a cormus-individual, consisting only of two regions, viz. that of enveloping phyllomes differentiated into a perianth (see S. No. 319) and that of sporophylls enveloped by the former.

S. No. 319. (cf. S. No. 317). In a flower we may distinguish:
1a. the floral receptacle, thalamus or torus (receptaculum). This term designates the floral axis or caulome part of the flower which bears its perianth and sporophylls; its internodes are mostly short, nevertheless they may develop into various dimensions and shapes. See S. No. 321.

Confer moreover p. 30.

1b. the floral belts or girdles. The phyllomes of the flower may be divided according to their plastics into one to four main groups, occupying each a separate zone on the floral receptacle. The phyllomes of every zone together are called a belt or girdle. The following terms are used here:

2a. the perianth (perianthium). It consists of the enveloping phyllomes and may comprise one or two floral belts. See S. No. 325.

3a. the heterochlamydeous perianth. The perianth consists of two floral belts. They are called:

4a. the calyx (calyx). The outer belt of the perianth; the phyllomes are often green and of a firm texture.

5a. the epicalyx (epicalyx). This term designates an accessory calyx, outside a true calyx, formed by the stipules of the sepals, so that their number depends upon that of the latter. *Fragaria vesca*; *Potentilla anserina*; *Hagenia abyssinica.*

N.B. The involucre of a single flower is sometimes inappropriately called epicalyx.

4b. the corolla, the inner belt of the perianth; the phyllomes are often petaloid.

3b. the perigon (perigonium) or homoichlamydeous perianth, consisting of one belt. The phyllomes may be arranged in two different whorls; in such cases slight differences between the phyllomes of the outer and the inner whorl may be present. When these differences get more important, transitions unto the heterochlamydeous perianth may ensue and then systematical relations are often taken into account. For the flowers of Monocotyledons e.g. many botanists always use the term perianth, even if the two whorls of the perianth show a considerable difference in their plastics.

With respect to the characters exhibited by the members of the perigon, we may distinguish:

4a. the calycine perigon (calycinus), showing the ordinary characters of a calyx. *Urtica urens.*

4b. the corollaceous (corollaceus) or petaloid (petaloideus) perigon, showing the ordinary characters of a corolla. *Hemerocallis flava.*

2b. the organs of reproduction (organum generationis) or micro- and megasporophylls, comprising also two floral belts:

3a. the androecium (androecium). This term designates the microsporophylls collectively. They produce pollen and often appear in the shape of stamens (see S. No. 335).

3b. the gynoecium (gynoecium). This term designates the megasporophylls collectively. They produce ovules and in *Angiospermae* appear in the shape of pistils (see S. No. 355).

1c. effigurations (effiguratio). This term designates somewhat conspicuous outgrowths of some of the above-mentioned members, forming more or less independent parts of the flower. In some cases they appear in the shape of appendages of the surface, anatomically exhibiting the characters either of trichomes or of emergences. They will be mentioned in their proper places.

1d. the floral nectaries (cf. S. No. 75). They belong to the receptacle, to the perianth, to the sporophylls or to the effigurations and will be mentioned in their proper places. See S. No. 324.

S. No. 320. (cf. S. No. 317). Parts of doubtful nature. Some parts belonging by their plastic characters to the floral receptacle and therefore generally dealt with in the description of this part must be considered nevertheless as possessing a somewhat doubtful nature. Tubular, cup- and pitcher-shaped parts bearing perianth and androecium and surrounding the gynoecium may afford examples (see S. No. 322, 323, 354, 362 and 399). They are considered by some botanists as representing outgrowths of the receptacle, bearing at their margin the displaced perianth and stamens (Payer, Hofmeister and Sachs). Other botanists however as positively maintain that they correspond to basal parts of members of the perianth and androecium united together by adnation (Van Tieghem, Velenovsky).

S. No. 321. (cf. S. No. 317). Concerning the floral receptacle the following subjects will be dealt with:

1a. parts of the receptacle. See S. No. 322.
1b. effigurations. See S. No. 323.
1c. floral nectaries. See S. No. 324.

S. No. 322. (cf. S. No. 321). The floral receptacle (cf. S. No. 319). It may be cylindrical, conical, plate-, cup-, or pitcher-shaped, in the latter cases being of a more or less doubtful nature, and in it we may distinguish the following parts:

1a. the hypanthium or hypanthial receptacle (hypanthium). It is the stalk or stipe bearing the calyx.

1b. the anthophore (anthophorum). It is the stalk or stipe bearing the corolla.

1c. the androphore (androphorum). It is the stalk or stipe bearing the androecium.
1d. the gynophore or thecaphore (gynophorum). It is the stalk or stipe bearing the gynoecium.

S. No. 323. (cf. S. No. 321). Effigurations of the receptacle. Here we may distinguish:
1a. the disc (discus). This term designates formations corresponding to local outgrowths of the receptacle, annular, plate-, or cup-shaped and of more or less doubtful nature. According to its position with respect to the stamens the disc may be:
  2a. extrastaminal. It is placed on the outside of the stamen belt; mostly between stamens and corolla, as in many *Sapindaceae* and *Capparidaceae,* much more rarely between corolla and calyx as in many *Apocynaceae.*
  2b. intrastaminal. It is placed on the inside of the stamen-belt between them and the carpids, as in *Anacardiaceae* and *Rhamnus Frangula.*
  2c. central. It is placed in the centre of a male flower and surrounded by the stamens, as in many *Euphorbiaceae.*
1b. discal glands (mostly nectaries), and discal scales. They are outgrowths of the disc representing appendages of the surface, often being emergences. Examples of discal glands are afforded by *Reseda* and *Capparidaceae* (*Cristatella, Cadaba*); of discal scales by *Passiflora* and *Bridelia* [1]).

S. No. 324. (cf. S. No. 321). Nectaries of the receptacle. They appear as parts of the surface of the disc or as discal glands (cf. S. No. 323), but no special terms are in use.

S. No. 325. (cf. S. No. 317). Concerning the perianth the following subjects will be dealt with:
1a. the organotactics and plastics of its members. See S. No. 326.
1b. subdivisions of the perianth; tube, limb and throat. See S. No. 327.
1c. degree of adnation between the members. See S. No. 328.
1d. parts of members in polyphyllous perianth, claw and limb. See S. No. 329.
1e. general shape. See S. No. 330.
1f. effigurations of the perianth. See S. No. 331.
1g. nectaries of the perianth. See S. No. 332.

S. No. 326. (cf. S. No. 325). According to the organotactical and plastic characters of the members of the perianth we may distinguish:
1a. phyllomes.
  2a. sepals (sepalum). The members of the calyx.
  2b. petals (petalum). The members of the corolla.

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[1]) Pax, Allg. Morphol. d. Pfl., Stuttgart 1890, p. 205.

2c. tepals (tepalum). The members of the perigon.

2d. nectaries (nectarium), representing complete phyllomes. *Aconitum Napellus; Eranthis hyemalis; Helleborus niger,* corolla.

2e. rudimentary scales. *Aconitum Napellus.*

2f. lodicules (lodicula). They are small scales representing members of the perigon and swelling when the flower is about to open. *Gramineae.*

1b. appendages of the surface.

The following terms are used here:

2a. the pilose perianth, consisting of trichomes, *Eriophorum spp.*, perigon.

2b. pappus (pappus), representing the calyx and mostly composed of trichomes, sometimes of emergences. *Taraxacum officinale; Carduus crispus; Valeriana officinalis.*

S. No. 327. (cf. S. No. 325). In the perianth consisting of phyllomes we may distinguish the following parts:

1a. the tube (tubus). The more or less cylindrical part.

1b. the limb or border (limbus). The flat horizontally extending part.

1c. the throat (faux [1]). The boundary between tube and limb.

The above terms are used by preference for gamophyllous perianths, but there is no objection to using them also for polyphyllous perianths; the corolla of *Cheiranthus Cheiri* may serve as an example (see S. No. 328).

S. No. 328. (cf. S. No. 325). With respect to the degree of concrescence or adnation between the members of the perianth we may distinguish:

1a. a polyphyllous perianth (polyphyllus). The members are free from one another. Here the following terms are in use:

2a. the polysepalous calyx (polysepalus). *Ranunculus acris.*

2b. the polypetalous corolla (polypetalus, choripetalus). Subclass of *Polypetalae* or *Choripetalae* in *Dicotyledons.*

2c. the polyphyllous or polytepalous perigon. *Fritillaria Imperialis.*

1b. a gamophyllous perianth (gamophyllus). There is adnation between the members; the degree of this adnation is described with the help of the same terms which are in use for the description of the depth of depending divisions in the margins of phyllomes (cf. S. No. 213), so that we may distinguish gamopetalous perianths with a lobed, split or parted limb or border. Here the following terms are in use:

2a. the gamosepalous calyx (gamosepalus). *Hyoscyamus niger.*

2b. the gamopetalous or sympetalous corolla (gamopetalus, sympetalus, monopetalus). Subclass of *Gamopetalae* or *Sympetalae* in *Dicotyledons.*

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[1] Although the nominativus of this word is not used in Latin, there is no better botanical term known to me.

2c. the gamotepalous or syntepalous perigon (gamophyllus). *Convallaria majalis.*

S. No. 329. (cf. S. No. 325). The members of the polyphyllous perianth may exhibit the following parts:

1a. the claw or unguis, the narrow base of the member. *Cheiranthus Cheiri, Dianthus.*

1b. the limb, blade, or lamina, the broad apical part of the member.

S. No. 330. (cf. S. No. 325). With respect to shape we may distinguish:

1a. The actinomorphous, regular or radially symmetrical perianth (cf. S. No. 52) (actinomorphus and regularis).

2a. wheel-shaped or rotate (rotatus); large limb and small tube. *Reseda odorata, Ranunculus acris,* calyx; *Myosotis palustris, Specularia speculum, Ranunculus Ficaria (Ficaria ranunculoides),* corolla; *Ornithogalum nutans,* perigon.

2b. tubular (tubulosus); large tube and small limb. *Dianthus spp., Lychnis dioica* ♂, calyx; *Senecio vulgaris* and many other *Compositae,* corolla; *Polygonatum officinale,* perigon.

2c. salver-shaped or salver-form, (hypocrateriformis), tube and limb both well developed; *Fuchsia globosa, Rosa pomifera,* calyx; *Syringa vulgaris, Phlox Paniculata (Phlox decussata),* corolla; *Narcissus spp.,* perigon.

2d. pitcher-shaped (urceolatus); tube spherical, limb slightly developed. *Physalis Alkekengi, Silene Cucubalus* (*S. inflata*), *Lychnis dioica* ♀, calyx; *Erica Tetralix,* corolla; *Muscaria botryoides,* perigon.

2e. funnel-shaped (infundibuliformis), exhibiting the shape of a funnel. *Primula obconica, Convolvulus arvensis,* calyx; *Calystegia sepium (Convolvulus sepium), Datura Stramonium* corolla; *Ulmus campestris,* perigon.

2f. bell-shaped, exhibiting the shape of a bell (campanulatus). *Hibiscus syriacus* and *Atropa Belladonna,* calyx; *Campanula spp.,* corolla; *Hyacinthus orientalis,* perigon.

1b. the zygomorphous, dorsiventral or irregular perianth.

2a. calcarate or spurred (calcaratus), provided with a more or less cylindrical hollow appendage, mostly containing nectar, and called spur (calcar). *Tropaeolum majus* and *Delphinium Consolida,* calyx; *Viola odorata* and *Delphinium Consolida,* corolla; *Orchis spp.,* perigon.

2b. labiate or ringent (labiatus). Tube well developed, limb divided into two parts: the upper lip (labium superius) and the lower lip (labium inferius), the mouth of the perianth being open and gaping. *Thymus Serpyllum* and *Prunella vulgaris,* calyx; *Labiatae* and *Lonicera Caprifolium,* corolla.

2c. personate or masked (personatus). Labiate, the lower lip with a fold, called palate (palatum), with which the tube is closed. *Antirrhinum majus, Linaria Cymbalaria, L. vulgaris,* corolla.

2d. papilionaceous or butterfly-shaped (papilionaceus). Here we may distinguish the following parts:

3a. the keel or carina (carina), formed by two petals of which the limbs have been united together; it is turned downwards.

3b. the alae, leeboards, sails or wings (ala), two petals placed laterally each on one side of the keel. See moreover M. N. No. 23.

3c. the standard or vexillum (vexillum). The fifth petal covering the alae and turned upwards; it is often strongly developed, folded along its midrib and possesses an emarginate apex, thus often resembling the wings of a butterfly. Examples are afforded by all *Papilionaceae,* like *Pisum, Lathyrus, Trifolium,* etc.

2e. ligulate or strap-shaped (ligulatus), tube more or less developed, limb on the adaxial side with a single very deep incision between two members of the perianth, the latter on the abaxial side strongly grown out, flat strap-shaped and provided at the top with some small teeth which may however be wanting. *Taraxacum officinale* and many other *Compositae.*

S. No. 331. (cf. S. No. 319 and S. No. 325). Effigurations of the perianth. Corona (corona) is the term most generally in use for these effigurations, and designates a whorl of scales (squamae) on members of the perianth either free or united together.

Ranunculus spp., free squamae each on the claw of a petal; *Symphytum officinale,* free squamae in the tube of the corolla; *Myosotis spp.* and *Lychnis dioica,* free squamae on the throat; *Narcissus Jonquilla,* perigon, members of the corona united into a cylindrical continuation of the tube, above the limb.

S. No. 332. (cf. S. No. 325). Nectaries of the perianth. They appear as complete metamorphosed members of the perianth, (cf. S. No. 326), but also simply as parts of the surface of members of the perianth, as for instance the interior surface of spurs *(Tropaeolum majus, Orchis Morio, Viola tricolor).*

S. No. 333. (cf. S. No. 317). Concerning the androecium the following subjects will be dealt with:

1a. phyllome nature of its members. See S. No. 334.
1b. meaning of the term stamen. See S. No. 335.
1c. description of the parts of a stamen. See S. No. 336.
1d. number of stamens. See S. No. 343.
1e. hypo-, peri- and epigynous insertion of stamens. See S. No. 344.
1f. relations of superposition of stamens. See S. No. 345.
1g. haplo- and diplostemonous androecium. See S. No. 346.

1h. unequal length of stamens: didynamous and tetradynamous. See S. No. 347.
1i. concrescence of filaments. See S. No. 348.
1k. syngenesious stamens. See S. No. 349.
1l. union between filaments and anthers. See S. No. 350.
1m. dehiscence of thecae. See S. No. 351.
1n. staminodes. See S. No. 352.

S. No. 334. (cf. S. No. 333). The members of the androecium as well as those of the perianth exhibit the common characters of phyllomes, although in their shapes and functions they are often very different from leaves. That they are considered in their different shapes, either stamens or otherwise, as microsporophylls (see S. No. 233) is a strong argument in favour of their phyllome nature. Stamens moreover sometimes show a tendency to be metamorphosed into petals or foliage leaves and this is illustrated by the following facts: 1. sometimes in the same flower the petals, being very numerous, towards the apex of the receptacle show gradual transitions into normal stamens, as in the flower of *Nymphaea alba*; 2. certain monstrosities are of very common occurrence in which the number of petals has been increased by transformation of stamens, occasionally even of carpids (see S. No. 354); examples are afforded by *Rosa gallica* (double flowers, flos duplex) and *Rosa centifolia* (full flowers, flos plenus); 3. in other monstrosities, virescences, there occur all transitional stages between stamens and foliage leaves.

S. No. 335. (cf. S. No. 333). Meaning of the term stamen. In its restricted sense this term designates microsporophylls of Angiospermae, being reduced phyllomes consisting of a simple stalk, bearing at its top mostly two bilocular synangia. See S. No. 337. But the use of this term is often extended to microsporophylls of Gymnospermae, occurring in strobili (*Pinus*, *Taxus*), especially when these are placed in whorls *(Cycadoidea, Gnetales);* never to microsporophylls borne by unspecialized cormus-individuals or cormus-parts *(Lyginopteris oldhamia)*.

S. No. 336. (cf. S. No. 333). Concerning the parts of the stamen the following subjects will be dealt with:
1a. the stamen itself, filament and anther. See S. No. 337.
1b. the pollen. See S. No. 338.

S. No. 337. (cf. S. No. 336). In stamens we may distinguish:
1a. the filament (filamentum). The more or less cylindrical stalk.

2a. gynostemium or column (columna). This term designates a combination of filaments or stamens with the style of the pistil. Where such a combination exists the terms gynandrous

flowers (flos gynandrus) and gynandrous plants (order of *Gynandrae)* may be used.
1b. the anther (anthera). The part producing pollen and placed at the top of the filament.

2a. the connective (connectivum). The prolongation of the filament in the anther, connecting the thecae.

2b. theca or lobe (cf. S. No. 99). Generally two in number, placed on both sides of the connective; they contain the pollen (pollen). See S. No. 339. Each theca is originally composed of two compartments or primitive pollen-sacs, called loculi (loculus), which by the destruction of a septum unite together at maturity.

S. No. 338. (cf. S. No. 336). Concerning pollen the following subjects will be dealt with:
1a. composition of pollen. See S. No. 339.
1b. external shape of pollen-grains. See S. No. 340.
1c. organography of contents of the pollen-grains. See S. No. 341.
1d. germination of pollen-grains. See S. No. 342.

S. No. 339. (cf. S. No. 338). Composition of pollen (pollen) [1]. It is composed of pollen-grains which may be compared to the microspores of *Pteridophyta* (cf. S. No. 93) and it may occur as:
1a. a dusty powder. *Pinus sylvestris; Corylus Avellana.*
1b. a more coherent powder in consequence of the grains being mixed with remnants of the tapetum (see S. No. 721), as in *Malva sylvestris*, or with fine oily drops, as in *Lilium.*
1c. diplo-pollen [2]. A powder consisting of pollen-grains composed of two cells, each capable of producing a pollen-tube. Some *Podostemonaceae.*
1d. tetrad-pollen (see S. No. 484) [3]. A powder consisting of still more or less cohering tetrads (see S. No. 482), as in *Rhododendron ponticum.*
1e. sectile pollen (pollen sectile). This term designates a pollen divided into a certain number of lumps, consisting of numerous pollen-grains, all arising from one and the same archespore cell and joined together by an interstitial substance. *Neottiïnae,* among *Orchidaceae* [4].
1f. a pollinium [5]. This is the whole massa of pollen-grains,

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[1] The articles entitled pollen and external shape of pollen-grains have been revised in collaboration with Mr. P.-M. L. Tammes, who was making investigations concerning pollen in this laboratory under the guidance of Prof. Schoute. To Mr. Tammes I am indebted for several valuable suggestions, while also the article S. No. 94, on polarity of basis and apex in spores, is due to his initiative.

[2] Schürhoff, P. N. Die Zytologie der Blütenpflanzen, Stuttgart 1926. p. 248.

[3] Schürhoff l.c.; H. Fischer, Beiträge zur vergleichenden Morphologie der Pollenkörner. Diss. Breslau 1890. p. 18.

[4] Engler u. Prantl. Pfl. Fam. II, 6, 1889. p. 66 u. 67. The pollen lumps are designated here also as massulae.

[5] Pollinia and also the masses of sectile pollens have sometimes been called massulae, (Fischer l.c. p. 18), but this is no economical use of two well defined

joined together by an interstitial substance. *Asclepiadaceae* and *Orchidaceae.*

In it we may distinguish the following parts:

2a. the pollinium proper.

2b. the caudicle. A continuation of the interstitial substance forming a stalk for the pollinium proper.

2c. an adhesive disc. A glandular swelling at the lower end of the caudicle. *Orchis.*

S. No. 340. (cf. S. No. 338). External shape of pollen-grains. In describing the external shape of pollen-grains including conditions of their surface, it is necessary to use material in a dry state and also in a swollen state, such as the grains assume before their germination on the gynoeceum. The general shape of pollen-grains is mostly a very simple one, so that it often suffices to use one of the simple terms of solid geometry, enumerated in S. No. 31. Subordinate modifications of these shapes due to certain conditions of surface are by no means rare and the principal kinds are:

1a. grooves [1]. One or more, to be observed only on dry grains (excepting only *Ceratozamia mexicana,* exhibiting it in both conditions); if there are more than one, they may in a majority of cases be called meridian. *Lythrum Salicaria.*

1b. broad bands *(Lythrum Salicaria)* and narrow crests *(Vernonia)* protruding from the surface, but all of relatively considerable dimensions.

1c. slighter projections, such as warts, small spines etc. *Althaea, Vernonia* (warts), and *Malva* (spines).

1d. places of exit for the pollen-tube in germination [2]. They appear on the surface mostly as small depressions in dry and also as small or more or less extended protuberances in swollen grains. They are: circular, oval, slit-like and in the latter case, they may even extend over the whole grain. Important are:

2a. number.

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terms, having in common only that they designate clusters of microspores or pollen-grains. Confer moreover S. No. 104.

[1] This subject is dealt with in detail by Fischer, l.c. Fischer uses the term parallel grooves (parallele Falten) for indicating the "meridian grooves" of the text.

[2] The places of exit often show a certain correlation with the formation of the exine in the wall of the pollen-grain. This subject cannot be dealt with here, but for a student describing pollen-grains, it may be important to direct his attention towards a paper by Roger P. Wodehouse entitled: The phylogenetic value of pollen-grain characters, Annals of Botany 1928, Vol. 42, p. 891. At the end of this paper the author has given a Glossary, containing 25 special terms, useful for the construction of elaborate pen-portraits of pollen-grains and specially adapted for the genus *Vernonia.* These terms are the following:

Abporal lacunae; Circumpolar lacunae; Cribellate; Echinate; Echinolophate; Equatorial crest; Equatorial lacuna; Expansion fold; Germinal aperture, Germ pore, Germinal pore; Germinal furrow; Interlacunar crest; Interporal lacunae; Lacunae; Lophate; Monopored; Paraporal crests; Paraporal lacunae; Polar lacuna; Poral lacuna; Psilate; Psilophate; Subechinate; Subechinolophate; Sublophate; Tricolpate.

3a. a single one, is of very frequent occurrence and may be observed in all *Gymnospermae* with exception of *Gnetinae* and in most Monocotyledons.

3b. two occur now and then, e.g. in some *Bromeliaceae (Nidularium amazonicum)* and *Fuchsia fulgens.*

3c. three are again of most common occurrence, for instance in many *Dicotyledons,* like *Onograceae, Tiliaceae.*

3d. larger numbers are by no means rare, as in: *Gossypium herbaceum* (4—8), *Hibiscus syriacus* (10—20), *Beta trigyna* (25—30), *Atriplex hortensis* (about 50), *Althaea rosea* (about 100).

2b. arrangement, on the surface of the pollen-grain.

3a. only one place of exit.

4a. basisiphonic pollen-grains. Confer S. No. 94, where examples also have been given.

4b. acrosiphonic pollen-grains. Confer S. No. 94, where examples also have been given.

3b. more than one place of exit.

4a. equatorial arrangement. The places of exit are arranged in an equatorial plane. *Lythrum Salicaria, Oenothera* and *Rafflesia* (3); *Impatiens sultani* (4—6); *Polygala amara* (10—11); *Welwitschia mirabilis* (about 20).

4b. scattered over the surface, and more or less regularly arranged. *Malva sylvestris.*

S. No. 341. (cf. S. No. 338). Organography of contents of pollen-grains. Pollen-grains, being comparable to microspores or male spores, give rise to strongly reduced male prothallia, antheridia and gametes and in this respect when the pollen-grains are ripe and ready for pollination the following cases may occur:

1a. each pollen-grain contains a prothallium consisting of a relatively large number (for instance twenty) cells. *Stephanospermum.*

1b. each pollen-grain contains a single small prothallium cell and a large antheridium cell, the latter dividing into a small generative cell and a large tube cell. From the generative cell there develop a sterile stalk cell and a spermatozoid mother cell, giving rise to two spermatozoids. From the tube cell is developed a haustorial pollen-tube (see S. No. 342, 1a). *Dioon* and all other *Cycadaceae; Ginkgo biloba* exhibits much the same phenomena.

1c. each pollen-grain contains two small prothallium cells and one large cell. The latter is destined to be divided into a tube cell and a generative cell. The pollen-tube brings the generative cell in the vicinity of the egg-cell. The generative cell produces two male cells (*Taxodium*) or two male cell nuclei (*Pinus*). *Coniferae.*

1d. each pollen-grain contains a large pollen-tube cell and clearly delimited from it a small antheridium mother cell, but prothallium cells are wanting. The tube cell is destined to produce the pollen-tube through which the antheridium mother cell, dividing into two male or generative cells, is brought to its destination. *Angiospermae.*

S. No. 342. (cf. S. No. 338). Germination of pollen-grains. After pollination (the conveyance of the ripe pollen-grains towards the parts of the gynoeceum fit for receiving them) the germination of pollen-grains takes place and a pollen-tube is formed of which two different kinds exist:
1a. from pollen-grains destined to produce spermatozoids, as in *Cycadaceae,* there is formed a pollen-tube in a direction opposite to that in which the generative cell is turned. This tube is strongly branched and from the pollen-chamber of the ovule in which the pollen-grain is placed it penetrates into the tissue of the integument performing the functions of a haustorium.
1b. from pollen-grains, like those of the higher plants not producing spermatozoids, there is formed an unbranched often very long pollen-tube on the side where the generative cell lies and through this tube the generative cell or its descendants move towards the egg-cell,

S. No. 343. (cf. S. No. 333). The number of stamens constitutes a very important character and ought to be mentioned in every description. If however there are more than twenty, the terms many stamens, indefinite number of stamens and polyandrous flowers are used, but the exact number ought to be determined.

S. No. 344. (cf. S. No. 333). Although the stamens are inserted upon the floral receptacle, there may occur cases of displacement and adnation in which it seems that they arise from calyx or corolla. This led De Candolle in his system to set up three important subclasses of Dicotyledons:
1a. hypogynous insertion. See S. No. 379.
  2a. the stamens are simply inserted upon the floral receptacle. Subclass of *Thalamiflorae.*
1b. perigynous and epigynous insertion. See S. No. 136 and 379.
  2a. the stamens in consequence of displacement seem to be inserted upon the calyx. Subclass of *Calyciflorae.*
  2b. the stamens in consequence of adnation seem to be inserted upon the corolla. Subclass of *Corolliflorae*: *Compositae, Boragineae.*

S. No. 345. (cf. S. No. 333). With respect to relations of superposition the following terms are used:
1a. episepalous, antisepalous or alternipetalous stamens. They are superposed on the sepals and alternating with the petals. *Erodium cicutarium* (whorl of antipetalous staminodes, see S. No. 352).
1b. epipetalous, antipetalous or alternisepalous stamens. They are superposed on the petals and alternating with the sepals. *Frangulinae.*
1c. epitepalous or antitepalous stamens. They are superposed on the tepals. *Urticinae,* for instance *Ulmus campestris.*

S. No. 346. (cf. S. No. 333). If the stamens are arranged in whorls we may distinguish with respect to the number of these whorls combined with relations of superposition:
1a. the haplostemonous androecium. It consists of only one whorl of stamens. The terms haplostemonous flower or haplostemonous plant may also be used. *Compositae.*
1b. the diplostemonous androecium. It consists of two whorls of stamens. The terms diplostemonous flower or diplostemonous plant may be used. *Lilium, Berberis.*
In connection with superposition:
2a. the obdiplostemonous androecium. The stamens of the outer whorl are antipetalous. *Ericaceae; Rhodoraceae.* The term obdiplostemonous flower or obdiplostemonous plant may also be used.
1c. the number of whorls may be increased, but for these cases no special terms are in use. *Rosa.*

S. No. 347. (cf. S. No. 333). The length of all stamens is often the same, but there are numerous exceptions, for instance in *Cassia* where the stamens of the abaxial side are long and those of the adaxial side are short, partly even abortive. Where this phenomenon occurs regularly we may distinguish:
1a. cases exhibiting a connection between the dorsiventrality of the flower and the different length of the stamens, as in heterotristylous flowers of *Pontederia* and *Eichhornia.* For a special and important case of this kind we use the term:
2a. didynamous stamens (didynamus). There are four stamens, two long and two short ones, all belonging to the same whorl and here it ought to be mentioned whether the adaxial or the abaxial ones are longer. *Labiatae* and *Scrophulariaceae.*
1b. cases exhibiting no connection with dorsiventrality, but exclusively the consequence of differences in length between stamens belonging to different whorls, as in heterotristylous flowers of *Dicotyledonae*: *Oxalis rosea.* For a special and important case of this kind we use the term:
2a. tetradynamous stamens (tetradynamus). There are four long stamens and two short. *Cruciferae.*

S. No. 348. (cf. S. No. 333). With respect to the concrescence of the filaments we may distinguish:
1a. monadelphous stamens (monadelphus). All filaments are united into a single tube. All *Malvaceae,* for instance *Althaea officinalis;* many *Papilionaceae,* for instance *Laburnum anagyroides (Cytisus Laburnum).*
1b. diadelphous stamens (diadelphus). Filaments united into two bundles. Many *Papilionaceae* (9+1), for instance *Trifolium, Coronilla varia*; *Fumaria officinalis.*
1c. polyadelphous stamens (polyadelphus). Filaments united into more than two bundles. *Ricinus communis*; *Citrus aurantium*; *Hypericum spp.*

S. No. 349. (cf. S. No. 333). Syngenesious stamens (syngenesis, adject.). This term designates stamens of which the anthers are coherent into a tube. Family of *Compositae; Solanum tuberosum; Viola tricolor; Gentiana Pneumonanthe.*

S. No. 350. (cf. S. No. 333). With respect to the mode of union between anther and filament we may distinguish:
1a. innate anthers (innatus). Filament attached to the base of the anther. *Ranunculus spp.*
1b. adnate anthers (adnatus). Filament attached along the whole length of the anther. *Magnolia acuminata.*
1c. versatile anthers (versatilis). Filament attached movably to a small part of the anther often lying in the middle of its length. *Lilium spp.;* family of *Gramineae.*

S. No. 351. (cf. S. No. 333). There are various modes of dehiscence of thecae (dehiscentia). It may take place:
1a. with a longitudinal slit (longitudinaliter dehiscens) or along a longitudinal suture or line of dehiscence.
  2a. introrse (introrsum). Towards the centre of the flower. *Viola spp.; Compositae.*
  2b. lateral or marginal (lateraliter). *Begonia spp.; Fritillaria Imperialis.*
  2c. extrorse (extrorsum). Towards the perianth. *Iris Pseudacorus.*
1b. with a pore (poro dehiscens). An aperture mostly at the top of the theca. *Solanum tuberosum; Rhododendron ponticum.*
1c. by uplifted valves (valvis dehiscens). One or more in number. *Berberis vulgaris.*

S. No. 352. (cf. S. No. 333). Staminodes (staminodium). This term designates organs corresponding in place and developmental characters to stamens, but not producing pollen. *Scrophularia nodosa; Parnassia palustris; Salvia pratensis.*

S. No. 353. (cf. S. No. 317). Concerning the gynoecium the following subjects will be dealt with:
1a. phyllome nature. See S. No. 354.
1b. meaning of the term pistil. See S. No. 355.
1c. ovary with ovules, style, stigma. See S. No. 356.
1d. simple and compound pistils. See S. No. 360.
1e. apocarpous and syncarpous gynoecium. See S. No. 361.
1f. superior and inferior ovary. See S. No. 362.
1g. unilocular and plurilocular ovary. See S. No. 363.
1h. complete and incomplete dissepiments. See S. No. 364.
1i. true and false dissepiments. See S. No. 365.
1j. placentae. See S. No. 366.
1k. structure of ovules. See S. No. 367.
1l. position of ovules in the ovary. See S. No. 368.

1m. stylopode. See S. No. 369.
1n. carpodes. See S. No. 370.
1o. nectaries. See S. No. 371.
1p. floral formula. See S. No. 372.

S. No. 354. (cf. S. No. 353). The gynoecium is composed of one or more carpids or carpels (carpellum). They are considered as megasporophylls (cf. S. No. 233) and this is a strong argument in favour of their phyllome nature. Moreover they show in some monstrosities a tendency to appear in the shape of green leaves, the so-called phyllomania of carpids, as in some full flowers (cf. S. No. 334).

By induplication (cf. S. No. 257) or concrescence of carpids, often also by both together, the gynoecium may be transformed into a pistil and then in epigynous flowers cup-shaped or tubular receptacles, although of somewhat doubtful nature, may take part moreover in the formation of the gynoecium (See S. No. 379).

S. No. 355. (cf. S. No. 353). Meaning of the term pistil. In *Gymnospermae* the megasporophylls or carpids occur in various shapes for which the following cases may serve as examples: 1. *Pecopteris pluckeneti,* whose megasporophyll was a fern leaf with hundreds of ovules developing into true seeds hanging down from its under side; 2. *Cycas* whose megasporophyll in many respects appears as a pinnate leaf bearing ovules at its margins: 3. *Coniferae,* whose megasporophylls show a strong tendency to reduction, so that they appear in the shape of leaf-scales or are even still further reduced and sometimes, as in *Taxus*, apparently wholly wanting, while several controversies exist in Botany about their more special nature (cf. S. No. 299). But with respect to *Gymnospermae* the term pistil is never used.

The use of this term is limited to the group of *Angiospermae,* because only here the megasporophylls singly or together always form a kind of case containing the seeds, and as has been mentioned above only a gynoecium exhibiting this character in consequence of plication or concrescence or of both together, is called a pistil. Hence a stricter definition for the term pistil is possible than for the term stamen, because in the latter case there does not exist a single unequivocal character separating *Gymnospermae* and *Angiospermae.*

S. No. 356. (cf. S. No. 353). In a pistil we may distinguish the following parts:

1a. the ovary (ovarium). The basal part having one or more cavities containing the ovules (ovulum). See S. No. 357.

It may exhibit the following parts:

2a. the wall of the ovary. The outer part.

2b. the dissepiments. They are partitions more or less dividing the cavity within the wall and if this division is complete the ensuing smaller cavities, are called loculi (loculus) or cells (see S. No. 363 and S. No. 364). Most dissepiments correspond to the united sides of two cohering carpids, but in a few cases they are:

3a. outgrowths of the midribs of carpids. See S. No. 365.

3b. outgrowths of the placentae. *Cruciferae.*

2c. the placentae (placenta). Those parts to which the ovules are attached.

1b. the style (stylus). A mostly elongated part borne by the ovary. A pistil may possess more than one style and the number of these often corresponds to that of the carpids.

In the style there may be a stylar canal (canalis stylinus), leading from the stigma towards an internal cavity of the ovary containing the ovules. This canal may appear partly or totally filled by a more or less loose tissue, called conducting or conductive tissue (tela conductrix). See S. No. 722. The pollen-tube of plants not possessing spermatozoids makes its way from the stigma towards the ovary through the conductive tissue.

1c. the stigma (stigma). The viscous part of the ripe style mostly appearing at its apex, on each style one or more in number.

2a. commissural stigmata. This term designates stigmata formed by concrescence of the margins of two adjacent carpids, so that the stigmata correspond in position to the dissepiments. *Eupapaveraceae.*

S. No. 357. (cf. S. No. 356). Concerning ovules the following subjects will be dealt with:

1a. component parts. See S. No. 358.

1b. organography of contents of embryo sac. See S. No. 359.

S. No. 358. (cf. S. No. 357). Ovules (ovulum). They are produced in the ovaries of pistils in *Angiospermae,* but it ought to be kept in mind that in other cases, as in *Gymnospermae* they are formed on open megasporophylls having the shape of scale leaves, sometimes reduced to a collar-like outgrowth below the ovule *(Ginkgo biloba)* or utterly wanting (*Taxus baccata*). These non-enclosed ovules however exhibit all essential characters belonging to those in pistils, so that both together will be dealt with here. Thus taking the term in a somewhat wider sense we may distinguish the following parts:

1a. the funicle (funiculus). The stalk which attaches the ovule to the placenta. In non-enclosed ovules this part is mostly wanting. On the other hand it sometimes gives rise to outgrowths persisting in the seed; they are:

2a. aril (arillus). Becoming a complete investment of the ripe seed. *Taxus baccata*; *Nymphaea alba.*

2b. strophiole (strophiola). Becoming a small protuberance of various shapes in the ripe seed. *Viola tricolor; Chelidonium majus; Colchicum autumnale.*

1b. the raphe (raphe). If a tissue similar in character to the funicle runs along the ovule for a certain distance, this part is designated by the term raphe.

1c. the integuments. They are more or less tubular investments of the ovule arising from the chalaza and exhibiting at their top an aperture, called micropyle (micropyle) or foramen. In the ovules of Gymnospermae the micropyle usually is borne by a slender prolonged part of the integument or of one of the integuments and thus protrudes beyond the scaly parts of the inflorescence so that the microspores may reach the micropyle.

Through the micropyle the microspores pass to the pollen chamber *(Cycas)* or the pollen-tube enters it, conducting the male cells to the nucellus *(Lilium)*. In a certain number of cases however the pollen tube does not enter the ovule through the micropyle, but finds its way through the chalaza towards the embryo sac; this phenomenon is called chalazogamy *(Casuarina; Juglans regia)*.

The micropyle is sometimes covered by a placental outgrowth, called obturator, which receives the pollen-tube and disappears after fertilisation *(Euphorbiaceae)*.

With respect to the number of integuments we may distinguish:

2a. the monochlamydeous ovule (monochlamydeus). Having only a single integument.

2b. the dichlamydeous ovule (dichlamydeus). Having two integuments.

3a. an outer or external integument or primine (integumentum exterius). This is the outer coat of the ovule and its aperture is called exostome (exostomium). The margin of the exostome may give rise to two kinds of outgrowths which persist in the seed; they are:

4a. the caruncle (caruncula). Becoming a wart or protuberance in the ripe seed. *Euphorbia spp.; Ricinus communis.*

4b. the arillode (arillodium). Becoming a complete investment of the ripe seed. *Euonymus europaeus; Myristica fragans,* mace, partly.

3b. an inner or internal integument or secondine (integumentum interius). This is the inner coat of the ovule and its aperture is called endostome (endostomium).

For examples of the several integuments mentioned above see Engler und Prantl, Pflanzenfamilien, 2. ed., 14a, 1926, p. 49.

1d. the nucellus or kernel of the ovule (nucellus). The internal and essential part of the ovule. It may exhibit the following parts:

2a. the chalaza (chalaza). This is the basal part of the ovule where the nucellus is inserted.

2b. the embryo sac (saccus embryonalis). This is in the more apical part of the nucellus, a single large cell, corresponding to a megaspore or female spore of *Pteridophyta.*

2c. the pollen-chamber. This is a cavity sometimes occurring at the top of the nucellus and into which the pollen-grains pass after pollination and produce spermatozoids or male cells. *Pteridospermae; Cordaites; Bennettites; Cycadaceae; Ginkgo; Ephedra.*

S. No. 359. (cf. S. No. 357). Organography of contents of embryo-sac. The embryo-sac, being comparable to a megaspore or female spore, gives rise to reduced and even strongly reduced female prothallia and archegonia, ultimately producing egg-cells and in this respect when the ovules are ripe for fertilisation the following cases may occur:
1a. each embryo-sac contains a female prothallium consisting of a rather large number of cells and producing a certain number of more or less reduced archegonia, as in *Cycadaceae, Ginkgo* and *Coniferae.* This prothallium is often designated also by the term endosperm of the ovule, and may grow out into the endosperm of the seed (See S. No. 408).
1b. the contents of the embryo-sac are still more reduced and here many different cases may occur which however have not given rise to a special terminology. Nevertheless there is in *Angiospermae* a very commonly occurring case in which we may distinguish:
  2a. a large central cell filling the principal part of the embryo-sac and containing the secondary cell nucleus of the embryo-sac formed by fusion of two so-called polar cell nuclei.
  2b. the egg-apparatus at the micropylar end of the embryo-sac consisting of:
    3a. an egg-cell.
    3b. two synergids (synergidae).
  2c. the antipodal cells, three in number at the chalazal end of the embryo-sac. Fertilisation by means of fusion with the generative cells of the pollen-tube takes place not only with the egg-cell, but also with the large central cell (*Angiospermae*).

With respect to the polar symmetry of basis and apex, exhibited in the very generally occurring case of *Angiospermae,* described above, we may distinguish: 1. the acrogamic embryo-sac. Confer S. No. 94, where examples also have been given. 2. the basigamic embryo-sac. Confer S. No. 94, where examples also have been given.

S. No. 360. (cf. S. No. 353). With respect to the number of its component carpids the pistil may be:
1a. simple (simplex). A single carpid. *Papilionaceae; Ranunculus.* See S. No. 361.
1b. compound. (compositus). More than one carpid, the number ought to be mentioned (bicarpellary, tricarpellary, etc.) *Pyrus Malus; Viola tricolor.* See S. No. 361.

S. No. 361. (cf. S. No. 353). With respect to the arrangement of the carpids in the gynoecium we may distinguish:
1a. the apocarpous gynoecium (the terms apocarpous pistils, apocarpous ovaries and apocarpous fruits cannot be used. See

morphological note N. 24. The term apocarpous flower is correct, but rather superfluous). The gynoecium is composed of one up to many simple pistils. In those pistils we may distinguish:

2a. the ventral[1]) suture. On the adaxial side of the carpid, corresponding to its margins and mostly bearing a longitudinal row of ovules.

2b. the dorsal suture. On the abaxial side of the carpid, corresponding to its midrib.

Examples are afforded by *Papilionaceae* and *Ranunculaceae.*

1b. the syncarpous gynoecium. The gynoecium consists of a single compound pistil. The term is synonymous with that of compound pistil and the use of the terms syncarpous pistil, syncarpous ovary, syncarpous fruit and syncarpous flower can be tolerated. See moreover M. N. No. 24.

S. No. 362. (cf. S. No. 353). According to the position of the ovary with respect to the insertion of the members belonging to the other belts of the flower we may distinguish:

1a. the superior ovary (superus). The free ovaries of hypogynous and epigynous flowers. See S. No. 379.

1b. the inferior ovary (inferus). The ovaries exhibiting adnation with the floral receptacles (although of somewhat doubtful nature) of epigynous flowers (see S. No. 379).

These terms were much used in former times. They comprise the same cases which are designated by the terms hypogynous, perigynous and epigynous flowers, which designate the same phenomena more correctly.

S. No. 363. (cf. S. No. 353). According to the number of cavities or loculi (loculus) occurring in the ovary it may be termed:

1a. unilocular or one-celled (unilocularis). The ovary of almost all simple pistils and of those compound ones formed of plain carpids by simple concrescence of their margins.*Papilionaceae* (exception: *Astragalus canadensis,* bilocular) ; *Reseda odorata* and *Viola tricolor.*

1b. plurilocular or several-celled. The ovary of all compound pistils arising from concrescence of involute or induplicate carpids. In these cases the number of loculi should be mentioned: bilocular or two-celled, as in *Solanum tuberosum, Capsella Bursa-pastoris;* trilocular or three-celled, as in *Iris Pseudacorus;* multilocular or many-celled, as in *Althea rosea* and *Malva.*

S. No. 364. (cf. S. No. 353). In all plurilocular and in some unilocular ovaries dissepiments (septum) more or less dividing the internal cavity occur and these may be:

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[1]) It is a curious fact that in this case the term ventral is used in Botany for the side which in other cases is called dorsal.

1a. complete (completus). Extending to the centre of the ovary. The ordinary case: *Pyrus Malus.*
1b. incomplete (incompletus). Not extending to the centre, so that the ovary remains unilocular. *Papaver somniferum.*

S. No. 365. (cf. S. No. 353). According to their origin the dissepiments may be:
1a. true (septum). Formed by the margins of the involute or induplicate concresced carpids. The ordinary case, e.g. *Funkia spp.*
1b. false or spurious (spurius). Formed as outgrowths of certain parts of the carpids, for instance their midribs (*Labiatae*; *Linum usitatissimum; Datura Stramonium)* or their placentae *(Cruciferae).*

S. No. 366. (cf. S. No. 353). According to the position of the placentae in the ovary (placentation, placentatio), we may distinguish:
1a. the parietal placenta (parietalis). At the circumference of the cavity in the ovary. *Pisum sativum; Viola tricolor.*
1b. the axile placentae (axillaris). In the centre of a plurilocular ovary. *Tulipa Gesneriana.*
1c. the central placenta (centralis). In the centre of a unilocular ovary, often cylindrical or conical. *Primula spp.; Rheum spp.*

S. No. 367. (cf. S. No. 353). According to the arrangement of its several parts with respect to one another the ovule may be:
1a. orthotropous, atropous or straight (atropus). Chalaza and insertion of the funicle at the base, micropyle at the top; relatively rare. *Cycas*; *Juglans regia*; *Rumex acutus*; *Piperaceae.*
1b. anatropous (anatropus). Micropyle and insertion of the funicle at the top, raphe running downwards to the chalaza at the base; the most common case. *Narcissus poeticus; Compositae; Violaceae; Umbelliferae.*
1c. semianatropous or amphitropous (semianatropus). Insertion of the funicle at a certain distance from the top, so that the raphe runs only along the lower part of the ovule, micropyle at the top, chalaza at the base.
1d. campylotropous (campylotropus). Chalaza and insertion of the funicle at the top in the vicinity of the micropyle, so that the nucellus shows an internal, not outwardly visible curvature; this case is not uncommon. *Cruciferae, Papilionaceae, Caryophyllaceae, Solanaceae.*
1e. camptotropous (camptotropus). Like campylotropous, but showing an externally visible curvature of the nucellus.

S. No. 368. (cf. S. No. 353). According to its position within the ovary the ovule may be:
1a. erect (erectus). Parallel to the longitudinal axis of the ovary,

insertion of the funicle turned towards its base. *Urticaceae, Piperaceae, Juglandaceae.*
1b. pendulous (pendulus). Parallel to the longitudinal axis of the ovary, insertion of the funicle turned towards its top. *Umbelliferae.*
1c. horizontal (horizontalis). Perpendicular to the longitudinal axis of the ovary.
1d. oblique. Placed obliquely to the longitudinal axis.
2a. ascendent (adscendens). Obliquely upwards. *Pyrus Malus.*
2b. descendent (descendens). Obliquely downwards. *Asarum europaeum*, the basal ovules.

Moreover the raphe of the anatropous ovule may be [1]:
1a. ventral (ventralis). Turned towards the placenta, i.e. lying between micropyle and placenta. *Euphorbiaceae* (Pax in Engler u. Prantl, Pflanzenfamilien).
1b. dorsal (dorsalis). Turned away from the placenta, i.e. the micropyle lying between raphe and placenta. *Aceraceae* (Pax, Ibid.).

S. No. 369. (cf. S. No. 353). Stylopode (stylopodium). This term designates an enlarged disc-like expansion excreting nectar and forming the base of the style. *Umbelliferae.*

S. No. 370. (cf. S. No. 353). Carpodes (carpodium) [2]. This term designates rudimentary carpids, as in flowers exhibiting phyllomania.

S. No. 371. (cf. S. No. 353). Nectaries of the gynoecium. The only term in use here is stylopode (cf. S. No. 369).

S. No. 372. (cf. S. No. 353). Concerning the floral formula the following subjects will be dealt with:
1a. relation between floral formula and diagram. See S. No. 373.
1b. floral formula. See S. No. 374.

S. No. 373. (cf. S. No. 372). Relation between floral formula and diagram. There is a close relation between floral formula and floral diagram, the former being in many respects a written diagram; its production is much less laborious than that of a floral diagram, but the latter is more complete and gives instruction concerning several points which are not or less clearly dealt with in the formula. Nevertheless the formula is able to denote two details which necessarily are wanting, at least in the horizontal or transverse floral diagram which is most commonly used: 1. the difference between a superior and inferior ovary, and 2. the adnation between members belonging to different whorls in the flower.

S. No. 374. (cf. S. No. 372). Floral formula or flower formula. It is composed of as many terms as there are floral belts or girdles in the flower, thus the formula of a complete flower contains four terms: calyx, corolla, androecium and gynoecium. These terms are denoted by letters: K = calyx, C = corolla, P = perigon, A = androecium, G = gynoecium, although some authors consider the use of these letters as superfluous. The terms are separated from one another by comma's and consist of figures corresponding to the number of members composing each belt; absent members are sometimes denoted by O; the symbol ∽ stands for many or indefinite. If a belt consists of several whorls, these are denoted by figures separated from one another by the symbol +.

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[1] Pax. Allgemeine Morphologie der Pflanzen. Stuttgart 1890, p. 270.
[2] Eichler, Blüthendiagramme, I. p. 4.

Lateral adnation between the members of a belt or whorl is expressed by enclosing the proper number within curved brackets (); lateral cohesion between floral belts reciprocally is denoted by enclosing members within square brackets [].

The superior or inferior position of the ovary is expressed by placing a horizontal line above or below the number of the carpids. Doubling or dédoublement of members may be denoted by adding the figures 2 or 3 as an exponent to the term.

Alternation or superposition of successive whorls generally is not expressed; nevertheless in the family of *Cruciferae* the alternation of the 4 petals with the four members of the calyx which corresponds to 2 whorls, is denoted by placing the symbol × before the term of the corolla.

If the flower is actinomorphous this may be expressed by placing the symbol * before the formula; if it is dorsiventral the symbol ·|· is used for this purpose and by varying the direction of this symbol it can be made clear whether the dorsiventrality is median ·|· , transverse ÷ or oblique ·/. [1]).

The symbols for male ♂ or female ♀ are placed, if necessary, before the formula.

Examples: *Lilium:* * P 3+3, A 3+3 G ($\underline{3}$); *Ranunculus bulbosus:* * K 5, C 5, A ∽, G $\underline{\backsim}$; *Cytisus Laburnum (Laburnum anagyroides):* ·|· K 5, C 5, A (5∓5), G $\underline{1}$; *Conium maculatum:* * K 5, C 5, A 5, G ($\overline{2}$): *Artemisia Absinthium,* disc-florets: * K O, [C (5), A (5)], G ($\overline{2}$); *Cruciferae:* * K 2+2, C ×4, A $2+2^2$, G ($\underline{2}$); *Corydalis:* ÷ K 2, C 2+2, Ā 2^3+O, G $\underline{2}$; *Labiatae:* ·|· K (5), [C̄ (5), A 4], G ($\underline{2}$); *Nymphaea alba:* * K 4, C ∽, A ∽, G ($\underline{\backsim}$); *Orchis:* ·|· P 3+3, [A 1+0, G ($\overline{3}$)]; *Salix alba:* ♂, A 2, G O and ♀, A O, G (2).

S. No. 375. (cf. S. No. 317). Special kinds of flowers. Concerning special kinds of flowers the following subjects will be dealt with:

1a. complete and incomplete flowers. See S. No. 376.

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[1]) By many botanists the symbol of an arrow pointing upwards ↑ or downwards ↓ is used for this purpose, but the symbol given in the text seems preferable, because it does not pretend to give an indication concerning a direction of the dorsiventrality.

1b. distribution, arrangement and developmental relations of the two sexes. See S. No. 377.
1c. general shape. See S. No. 378.
1d. hypo-, peri- and epigynous flowers. See S. No. 379.
1e. acyclic, cyclic and hemicyclic flowers. See S. No. 380.

S. No. 376. (cf. S. No. 375). With respect to the occurrence of the several floral belts the flower may be:
1a. complete (completus). The four belts are present.
1b. incomplete (incompletus). One or more belts are wanting. Here the following terms are in use:
2a. naked flowers (nudus). Perianth wanting. *Fraxinus excelsior.*
2b. neutral flowers (neutralis). Sporophylls wanting. *Centaurea Cyanus,* ray florets.

S. No. 377. (cf. S. No. 375). Kinds of flowers to be distinguished with respect to: 1. presence or absence of stamens and pistils; 2. spatial distribution of stamens and pistils in hermaphrodite flowers; 3. period of maturity of stamens and pistils in hermaphrodite flowers. Concerning these subjects confer S. No. 21, 1a, 1c, 1d.

S. No. 378. (cf. S. No. 375). With respect to general shape we may distinguish the following kinds of flowers:
1a. actinomorphous (cf. S. No. 52), radially symmetrical or regular (actinomorphus, regularis). *Iris Pseudacorus, Galanthus nivalis, Geranium Robertianum.*
2a. peloria or peloric flower. This term designates actinomorphic flowers appearing as monstrosities in a plant species which normally produces zygomorphic flowers. In describing a peloria it ought in the first place to be noted which parts of the normal flower correspond to those of the peloria. *Lamium maculatum, Betonica officinalis* and most other *Labiatae,* corolla of peloria composed of parts similar to the lateral lobes of the lower lip; *Calamintha Nepeta,* rarely corolla of peloria composed of parts similar to the median lobe of the lower lip; *Nepeta Mussini,* corolla of peloria composed of parts similar to a lobe of the upper lip; *Lupinus polyphyllus, Cytisus Laburnum, Trifolium repens,* corolla of peloria composed of parts similar to vexillum; *Genista genuensis,* corolla of peloria composed of parts similar to the alae 1).

According to their distribution on the plant we may distinguish:
3a. the terminal peloria. The lateral flowers of the plant are zygomorphous; only when terminal flowers are formed, which in the normal plants are wanting, they are peloric. *Digitalis purpurea var. peloria.*

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1) Examples after J. Peyritsch, Ueber Pelorien bei Labiaten. Sitz. ber. math. natrw. Cl. Akad. Wien 1870, p. 500 and O. Penzig, Pflanzen-Teratologie, Genua 1890, I p. 373.

3b. the lateral peloria. All flowers of the plant are more or less peloric. *Linaria vulgaris var. peloria; Antirrhinum majus var. peloria.*

1b. zygomorphous, dorsiventral, bilaterally symmetrical or symmetrical (dorsiventralis, zygomorphus, irregularis). In connection with zygomorphy the following terms are in use:

2a. according to the direction of the plane of symmetry, with respect to the median plane:

3a. medianly dorsiventral or medianly zygomorphous. The symmetry plane coincides with the median plane. *Lamium album; Antirrhinum majus.*

3b. transversely dorsiventral or transversely zygomorphous. The symmetry plane is directed transversely. *Corydalis lutea*; *Hibbertia* [1]) (*Hemipleurandra*) *trachyphylla*; *Hibbertia* (*Pleurandra*) *microphylla.*

3c. obliquely dorsiventral or obliquely zygomorphous. The symmetry plane is directed obliquely. Examples: *Solanaceae* with the exception of *Hyoscyamus,* (the symmetry plane passing through the first sepal); *Hyoscyamus* and *Malpighiaceae* (the symmetry plane passing through the third sepal); *Sapindaceae* and some *Boraginaceae* (symmetry plane passing through the fourth sepal); *Monnieria,* fam. of *Rutaceae* (symmetry plane passing through the fifth sepal); *Commelinaceae* (symmetry plane passing through the first tepal).

The original obliquity of these flowers mostly disappears in the adult state by means of a torsion taking place in the lower parts of the flower (resupination, reversion or inversion, see also 1b, 2b), so that the flower seems to be medianly dorsiventral.

2b. flowers provided with a labellum. The term labellum designates a conspicuous enlarged member of a zygomorphous flower; it may be a phyllome belonging to the perianth *(Orchis,* tepal) or it may be of staminodial origin *(Zingiber* and *Marantaceae);* it is always placed in a abaxial position, either because it has been developed there, or it may have been originally placed in an adaxial position, but has been turned by a torsion of the lower part of the flower through 180° (resupination, reversion or inversion), as in *Orchis maculata* where the labellum is at the same time provided with a spur.

1c. asymmetrical (cf S. No. 28 footnote). There is no symmetry plane dividing the flower into corresponding halves. This however does not mean that symmetry is altogether absent in all parts of the flower, but the asymmetrical condition may e.g. be brought about by a different position of the symmetry plane in the different belts of the flower. *Valeriana officinalis; Qualea macropetala; Canna indica.*

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[1]) Eichler. Blüthendiagramme II p. 250.

S. No. 379. (cf. S. No. 375). With respect to the shape of the floral receptacle and those parts of it which are of a somewhat doubtful nature (cf. S. No. 320), added to the position of the pistils (cf. S. No. 344 and S. No. 362) the flower may be:
1a. hypogynous (hypogynus). All parts of the receptacle are conical or cylindrical; insertion of perianth and stamens below that of the gynoecium; free superior ovaries. *Ranunculus repens; Geranium molle.*
1b. perigynous (perigynus). Those parts of the floral receptacle which are of a doubtful nature (cf. S. No. 320) have grown out into a cup-shaped or tubular cupule (cupula), at the margin of which perianth and stamens are inserted at a level higher than that of the gynoecium; free superior ovaries. *Rosa pomifera; Daphne Mezereum; Prunus Cerasus* and *Padus.*
1c. epigynous (epigynus). Those parts of the floral receptacle which are of a doubtful nature (cf. S. No. 320) are grown out cup-shaped or tubular, but there is adnation between these parts and the ovary, consequently the latter is not free; hence perianth and stamens apparently inserted on the top of the ovary; inferior ovaries. *Fuchsia globosa; Pyrus Malus; Umbelliferae; Compositae.*

S. No. 380. (cf. S. No. 375). With respect to its phyllotaxy the flower may be:
1a. acyclic (flos acyclicus). Spiral arrangement in all belts of the flower. *Adonis aestivalis*; *Helleborus niger*; *Aconitum Napellus.*
1b. cyclic (flos cyclicus). Verticillate arrangement in all belts of the flower. *Umbelliferae; Cruciferae* and many other families.

The total number of whorls composing a flower is sometimes mentioned and thus for instance we may distinguish:

2a. tetracyclic flowers and tetracyclic plants. *Tetracyclicae* among *Sympetalae,* e.g. *Gentianaceae, Asclepiadaceae,* etc.

2b. pentacyclic flowers and pentacyclic plants. *Pentacyclicae* among *Sympetalae,* e.g. *Ericaceae, Primulaceae.*
1c. hemicyclic (flos hemicyclicus). Spiral and verticillate arrangement combined in the same flower. *Ranunculus*; *Nymphaea alba*; *Paeonia officinalis.*

In the above cases each floral belt may consist of one or more spiral windings or whorls.

S. No. 381. (cf. S. No. 300). Fruit and seed. General description. Concerning the general description of fruit and seed the following subjects will be dealt with:
1a. meaning of the terms fruit and fruit proper. See S. No. 382.
1b. parts of the fruit besides the fruit proper. See S. No. 383.
1c. simple and accessory fruits. See S. No. 384.
1d. dry and fleshy fruits. See S. No. 385.
1e. pericarp and seed. See S. No. 386.
1f. wall of the pericarp, differentiations. See S. No. 387.

1g. dissepiments. See S. No. 391.
1h. placentae. See S. No. 392.
1i. dehiscence. See S. No. 393.
1j. special kinds of fruits. See S. No. 394.
1k. the seed. See S. No. 400.

S. No. 382. (cf. S. No. 381). The fruit in the most restricted and at the same time in the most commonly used sense of the word is a term designating a pistil and often only the ovary when fully developed in consequence of fertilisation and the term fruit proper is often used for it. It exhibits of course the same parts as the ovary, but, apart from their increased dimensions, these parts differ from those in two respects:
1a. they often show a higher grade of differentiation. See S. No. 388.
1b. in the ripe fruit there may appear a dehiscence leading to a dispersion of the seeds. See S. No. 393.

S. No. 383. (cf. S. No. 381). In addition to the fruit proper certain other members may grow out, so that they become parts of the fruit and are mostly considered as belonging to it. They are:
1a. the style and even the stigmata.
  2a. the stylopode. Confer S. No. 369.
  2b. the columella or carpophore. See S. No. 393.
1b. the calyx. *Pyrus communis; Nigella damascena; Physalis Alkekengi.*
  2a. the pappus. *Compositae: Taraxacum officinale, Aster Tripolium.*
1c. the perigon. *Morus nigra*; *Hippophaë rhamnoides.*
1d. the bracts. *Humulus Lupulus; Alnus glutinosa; Ananas sativus.*
1e. the cupule of *Cupuliferae* (cupula). This a part of most uncertain nature, coming to full development only in the ripe seed. *Quercus Robur*; *Fagus sylvatica*; *Castanea vesca.*
1f. the floral receptacle of a single flower. *Rosa pomifera; Fragaria vesca.*
1g. the peduncle of an inflorescence. *Ficus Carica; Ananas sativus.*

S. No. 384. (cf. S. No. 381). With respect to the characters of the parts composing it the fruit may be:
1a. simple. Exclusively formed by the fruit proper or if other parts should grow out with it, they constitute only subordinate elements of the fruit. *Gramineae; Funkia ovata.*
1b. accessory or anthocarpous. The other organs grown out together with the ovary constitute the main part of the fruit. *Fragaria; Humulus Lupulus.*
The term spurious fruit may be used if a group of fruits borne on an inflorescence has the appearance of a single fruit (*Ficus Carica, Morus alba).*

S. No. 385. (cf. S. No. 381). With respect to its consistency the fruit may be:

1a. dry (siccus). *Secale cereale; Umbelliferae; Lilium.*
1b. fleshy (carnosus). *Prunus Cerasus; Cucumis sativus.*

S. No. 386. (cf. S. No. 381). In a fruit proper we may distinguish:
1a. the pericarp (pericarpium). This term designates the whole fruit with the exception only of the seeds and comprising the following parts which correspond to the same in the ovary:
  2a. the wall. See S. No. 387.
  2b. the dissepiments. See S. No. 391.
  2c. the placentae. See S. No. 392.
1b. the seed. See S. No. 400.

S. No. 387. (cf. S. No. 381). Concerning the wall of the pericarp the following subjects will be dealt with:
1a. the several layers composing it. See S. No. 388.
1b. special differentiations in fruits arising from inferior ovaries. See S. No. 389.

S. No. 388. (cf. S. No. 387). The wall of the pericarp may exhibit the following differentiations:
1a. an exocarp or epicarp (exocarpium, epicarpium). The outermost layer.
1b. a mesocarp (mesocarpium). The middle layer.
  2a. a sarcocarp (sarcocarpium). This term designates a succulent mesocarp. *Prunus.*
1c. an endocarp (endocarpium). The innermost layer.

Examples are afforded by: *Prunus domestica* (skin, sarcocarp and stone); *Pyrus Malus* (skin, sarcocarp and core; the inner parts of the latter two belong to the dissepiments); *Citrus Aurantium* (flavedo, a thin leathery, coloured layer containing internal glands with essential oil; albedo, a thicker spongy white layer; the thick edible part is formed by internal emergences of the wall of the ovary and therefore may be considered as originally not forming a part of this wall.

S. No. 389. (cf. S. No. 387). The walls of fruits arising from inferior ovaries, having phyllomes inserted on their apical parts, may become costate by the presence of decurrent phyllomes (cf. S. No. 180). The following terms are here in use:
1a. ribs (jugum or costa). They are external, longitudinal more or less protruding ridges. See S. No. 390.
1b. valleculae (vallecula). The longitudinal furrows between certain ribs. *Umbelliferae:* four valleculae on each half or mericarp (see S. No. 393) of the fruit; there often occur in the tissue beneath the valleculae vittae (see S. No. 646), which may appear as slightly protruding longitudinal ridges (*Foeniculum vulgare).*

S. No. 390. (cf. S. No. 389). Among ribs we may distinguish:
1a. primary ribs. They correspond in position to the members

of the perianth and with respect to this character we may distinguish:

2a. carinal ribs (jugum carinale, costa marginalis). They correspond in position to the sepals. *Umbelliferae,* three on the adaxial half and two on the abaxial half of the fruit.

2b. commissural ribs (jugum commissurale, costa commissuralis). They correspond in position to the petals. *Umbelliferae,* two on the adaxial half and three on the abaxial half of the fruit.

Moreover with respect to their position on the carpids we may distinguish:

2c. marginal ribs (jugum marginale, costa marginalis). They are placed on the margins of those parts of the carpids which belong to the wall of the pericarp. *Umbelliferae,* at the margins of the halves of the fruit and here those of adjacent halves lie close together at the dissepiments *(Coriandrum sativum)* or they are distinct *(Foeniculum);* they may differ more or less from the dorsal ribs.

2d. dorsal ribs (jugum dorsale, costa dorsalis). They are placed between the marginal ribs. *Umbelliferae,* three dorsal ribs on each half of the fruit.

1b. secondary ribs. They are ribs placed between the primary ribs and are more or less developed, sometimes wanting, in other cases strongly developed and surpassing the primary ribs in size, as in *Coriandrum sativum* and *Daucus Carota.*

S. No. 391. (cf. S. No. 381). Dissepements. In fruits consisting of two carpids the single dissepiment is sometimes called commissure (commissura), as in the fruits of *Umbelliferae.* In this commissure of *Umbelliferae* there may occur vittae (see S. No. 646), which may appear as slightly protruding longitudinal ridges, as in *Coriandrum sativum.*

S. No. 392. (cf. S. No. 381). Placentae. In addition to the terms already mentioned in the description of the ovary, viz. parietal, axile and central placentation (cf. S. No. 366) we may distinguish in some cases:

1a. a replum[1]) (replum). This term designates a frame-like placenta (like a door-case), from which in dehiscence the adjacent parts (valves) fall away. Certain *Papaveraceae (Chelidonium majus); Mimosa; Cruciferae* (for this familiy the meaning of the term is mostly extended and includes also the spurious dissepiment remaining united with the placentae and being in fact formed by them).

S. No. 393. (cf. S. No. 381). With respect to dehiscence the fruits may be:

1a. indehiscent or non dehiscent (indehiscens). *Hordeum*

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[1]) Asa Gray. Botanical Text-book, part I, New York 1879, Structural Botany, p. 293 and glossary.

sativum; *Fagopyrum esculentum*; *Quercus Robur*; nearly all fleshy fruits, as in *Prunus* and *Pyrus*.

1b. dehiscent (dehiscens). Here we may distinguish:

2a. the schizocarp (schizocarpium). See moreover S. No. 396. The fruit splits into one-seeded portions, the so-called mericarps or split-fruits (mericarpium). These mericarps, after dehiscence, in some cases remain for some time united, hanging from the upper end of a columella (columella) or carpophore (carpophorum). This may take its origin:

3a. from a dissepiment, as in *Umbelliferae,* where in the commissure after dehiscence it is separated as a structure which bears the mericarps hanging from its upper forked end. *Foeniculum vulgare.*

3b. from the style, as in *Geraniaceae,* when it appears after dehiscence as the central part of the remaining style, while the mericarps are attached to its top by means of bands corresponding to the more peripheral parts of the style from which they are separated. *Geranium Robertianum*; *Erodium Cicutarium.*

Examples of schizocarps without columella are afforded by: *Galium Aparine*; *Acer Pseudo-Platanus*; *Tropaeolum majus*; *Labiatae*; *Boragineae; Malvaceae; Mercurialis annua; Euphorbia spp.*

2b. the capsule (capsula). See moreover S. No. 397. The fruit contains in each loculus more than one seed and is not split into separate portions, but when ripe, apertures are formed in various ways through which the seeds may escape and be scattered. In capsules the dehiscence may be:

3a. by splitting along the ventral suture of the capsule. *Paeonia officinalis; Delphinium Ajacis; Caltha palustris.*

3b. by valves (valva). The fruit splits lengthwise into valves which remain united mostly at their bases *(Papilionaceae; Myristica fragans),* sometimes at their tops *(Cruciferae).* For the rest, if such a fruit arises from a syncarpous gynoecium, the dehiscence may be:

4a. loculicidal (loculicidus). The valves are formed by fissures corresponding to the midribs of the carpids, so that each valve consists of two halves belonging to adjacent carpids. This is the case of most general occurrence. *Syringa vulgaris; Lilium; Iris.*

4b. septicidal (septicidus). The valves correspond to separated carpids; the dissepiments split into two layers; of less general occurrence. *Gentiana Pneumonanthe; Colchicum autumnale.*

4c. septifragal (septifragus). Loculicidal or septicidal, but the valves are separated from the dissepiments, which remain in the centre of the fruit. *Datura Stramonium; Erica Tetralix; Calluna vulgaris.*

4d. with a replum (replum). (cf. S. No. 392).

3c. by teeth (dens). Valves separating from one another only at their tops. *Lychnis Flos-cuculi; Cerastium arvense.*

3d. by clefts (rima). Valves remaining united at their bases and tops. *Orchideae; Oxalis spp.*

3e. by pores (porus) or poricidal (poricidus). Apertures mostly at the top or the base of the fruit. *Papaver spp.; Antirrhinum majus; Campanula spp.*

3f. circumscissile (circumscissilis, circumscissus). The upper portion of the fruit is thrown off in the shape of a circular lid (operculum). A capsule opening in this way is sometimes called a pyxis. *Hyoscyamus niger; Plantago spp.; Anagallis arvensis.*

S. No. 394. (cf. S. No. 381). Special kinds of fruits. Concerning special kinds of fruits the following subjects will be dealt with:

1a. dry, simple indehiscent fruits. See S. No. 395.
1b. schizocarps. See S. No. 396.
1c. capsules. See S. No. 397.
1d. fleshy simple fruits. See S. No. 398.
1e. accessory or anthocarpous fruits. See S. No. 399.

S. No. 395. (cf. S. No. 394). Among simple, dry, indehiscent fruits containing only a single seed we may distinguish:

1a. the caryopsis or grain (caryopsis). There is coherence between the wall of the pericarp and the seed-coat. *Gramineae,* e.g. *Triticum vulgare, Zea Mays.* Some caryopses, when ripe, remain enclosed within their paleae and then may be peeled, as in *Oryza sativa, Hordeum vulgare, Secale cereale, Avena spp.*

1b. the akene or achene (achenium). There is no coherence between the wall of the pericarp and the seed-coat and the wall of the pericarp is leathery. *Fagopyrum esculentum*; *Rosa gallica*; *Fragaria vesca; Compositae.*

1c. the nut (nux). There is no coherence between the wall of the pericarp and the seed-coat and the wall of the pericarp is more brittle, sometimes woody. *Quercus Robur; Fagus sylvatica; Castanea sativa (Castanea vesca); Corylus Avellana; Tilia platyphyllos.*

2d. the samara or key (samara monocarpellata). A winged nut. *Ulmus campestris; Fraxinus excelsior; Betula alba.*

S. No. 396. (cf. S. No. 394). Among schizocarps we may distinguish with respect to the number of portions into which they are divided and to the indehiscence or dehiscence of each portion:

1a. mericarps remaining closed.

2a. the diakenium or diachenium (diachenium). Splits into two mericarps. *Galium Aparine; Umbelliferae.*

3a. the double samara or double winged fruit (samara dicarpellata). *Acer Pseudo-Platanus.*

2b. the triakenium or triachenium (triachenium). Splits into three mericarps. *Tropaeolum majus.*

2c. the tetrakenium or tetrachenium (tetrachenium). Splits into four mericarps. *Labiatae; Boragineae.*

2d. the polyakenium, polyakena or polyachena (polyachenium). Splits into more than four mericarps. *Malvaceae.*

1b. mericarps opening.

2a. the dicoccous fruit (fructus dicoccus). Splits into two mericarps. *Mercurialis annua.*

2b. the tricoccous fruit (fructus tricoccus). Splits into three mericarps. *Euphorbia Helioscopia; Ricinus communis.*

2c. the pentacoccous fruit (fructus pentacoccus). Splits into five mericarps. *Geranium;* the fruit of the genus *Erodium,* although the mericarps remain closed, often are designated by the same term in consequence of their relationship.

S. No. 397. (cf. S. No. 394). Among capsules we may distinguish:
1a. arising from a simple pistil:

2a. the follicle (folliculus). The seeds are set free by dehiscence of the ventral suture only. *Paeonia officinalis; Delphinium Ajacis; Caltha palustris.*

2b. the legume (legumen). This is a follicle dehiscent along ventral and dorsal suture, so that two valves are formed. *Papilionaceae; Laburnum anagyroides (Cytisus Laburnum); Phaseolus multiflorus.*
1b. arising from a compound pistil:

2a. the silique (siliqua). This term designates a capsule composed of two carpids, cohering simply by their margins; nevertheless there is a complete spurious dissepiment corresponding to the outgrown parietal placentae; dehiscence by two valves remaining attached by their tops to the dissepiment, the seeds at first remaining fixed to the replum of the dissepiment. Many *Cruciferae: Brassica campestris* (*Brassica Napus*), *Hesperis matronalis.*

3a. the silicle (silicula). This term designates a silique which is as broad as it is long. Many other *Cruciferae; Cochlearia officinalis, Capsella Bursa-pastoris, Lunaria annua* (*Lunaria biennis*).

2b. the capsule proper. By this term are designated all capsules composed of two or more carpids and not being a silique. For the modes of dehiscence confer S. No. 393.

S. No. 398. (cf. S. No. 394). Among simple fleshy fruits we may distinguish:
1a. the berry (bacca). The seeds lie free in the fleshy part. *Ribes rubrum; Lycopersicum esculentum; Musa spp.; Vitis vinifera.*

2a. the dry berry. This term is sometimes used for designating a berry which, when ripe, becomes leathery and dry. *Capsicum annuum; Myristica fragans,* which moreover is dehiscent by two valves.
1b. the drupe or stone fruit (drupa). Mesocarp fleshy, endocarp sclerotic, so that the seeds lie within a stone (pyrena, putamen).

2a. the monopyrenous drupe (drupa monopyrena). With a single stone. *Prunus Cerasus; Prunus Persica; Olea europaea; Rubus Idaeus; Laurus nobilis; Prunus amygdalus; Juglans regia; Cocos nucifera.*

2b. containing more than one stone[1]).

3a. dipyrenous (dipyrenus). *Cornus sanguinea,* two cohering stones.

3b. tripyrenous (tripyrenus). *Sambucus nigra; Rhamnus Frangula.*

3c. tetrapyrenous (tetrapyrenus). *Ilex aquifolium.*

3d. polypyrenous (polypyrenus). Containing a larger and not strictly limited number of drupes. *Sararanga (Pandanaceae).*

1c. the apple or pome (pomum). Sarcocarp representing the mesocarp; endocarp leathery up to stony. *Pyrus Malus; Pyrus communis*; *Pyrus Aucuparia* (*Sorbus Aucuparia*).

1d. the pepo or gourd-fruit (pepo). A berry exhibiting an involute vernation of the carpids with a firm, more or less leathery outer part of the wall and often an internal cavity. *Cucumis Melo; Cucurbita Pepo*; *Cucumis sativus*; *Citrullus Colocynthis.*

1e. the hespiridium (hespiridium). A berry exhibiting an exocarp consisting of a thin leathery, coloured layer which contains internal glands with essential oil (flavedo), a mesocarp consisting of a thicker spongy white layer (albedo) and an endocarp developing a number of appendages of the internal surface, constituting a thick, often edible, sarcocarp. *Citrus Aurantium; Citrus Medica; Citrus nobilis; Citrus decumana.*

S. No. 399. (cf. S. No. 394). Among accessory or anthocarpous fruits we may distinguish:

1a. the fig fruit or syconus (syconium, syconus). The fleshy hollow peduncle of an inflorescence bearing many, often sterile, akenes. *Ficus Carica.*

1b. the strawberry. The fruit of *Fragaria vesca* and other species of the genus. The fleshy, somewhat conical receptacle of a single flower.

1c. the cynarrhodion (cynarrhodium). Like the strawberry, but the receptacle is grown out into a cupule (cf. S. No. 320); the fruits proper are sometimes called partial fruits or fruitlets. *Rosa spp.*

1d. the mulberry. An inflorescence of which the peduncle bears simple, dry, indehiscent fruits enclosed by a fleshy perigon. *Morus nigra.*

1e. the pine-apple. A spadix representing a simple spike bearing fleshy bracts and fruits. *Ananas sativus.*

1f. the cone (conus). An inflorescence sometimes representing a catkin of which the bracts are strongly developed, leathery or even woody. The fruits proper are akenes or nuts. *Alnus glutinosa; Humulus Lupulus.*

Although it is clear that strobili are not pistils and possess no ovaries, so that they never can produce true fruits, the term cone is habitually used for indicating the fertilised ripe seed-bearing strobili of *Pinaceae,* like *Pinus sylvestris, Picea excelsa* and many other *Gymnospermae,* like *Dioon, Bennettites,* etc. Galbulus (galbulus) is a special term generally used for strobili producing fleshy scales, as in *Juniperus communis; Juniperus Sabina (Sabina officinalis).*

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[1]) The term polypyrenous drupe (drupa polypyrena) has been used for this case, but it seems preferable to reserve this term for cases where a larger number of stones appears.

S. No. 400. (cf. 381). Concerning the seed the following subjects will be dealt with:
1a. meaning of the term. See S. No. 401.
1b. parts of the seed. See S. No. 402.
1c. development of a seedling from the seed. See S. No. 418.

S. No. 401. (cf. S. No. 400). The term seed designates an ovule when fully developed in consequence of fertilisation. It exhibits of course the same parts as the ovule but apart from increased dimensions shows differences of various kinds:
1a. some parts may show a higher grade of differentiation.
1b. other parts show reduction of some kind, often manifested by desiccation and shriveling (seed-coat) or resorption of whole tissues (nucellus).
1c. the development of the embryo from the fertilised egg-cell, a most important feature in the formation of the seed, though in seeds of plants of the Palaeozoic age the embryo apparently was still quite undeveloped at the time when the seed was ripe.

The correspondence between the several parts of the ovule and those of the seed is by no means always clear without a special investigation, and it ought always to be determined before making a description.

S. No. 402. (cf. S. No. 400). In a seed we may distinguish:
1a. the funicle (funiculus). It corresponds to the funicle of the ovule mentioned in S. No. 358. See moreover S. No. 403.
1b. the seed-coat, spermoderm or testa (spermodermis). The investing layer of the seed, corresponding to one or two integuments, but moreover completed at the base of the seed by other superficial layers and in the place of insertion of the funicle by internal tissues, so as to form a closed investment of the seed. The nucellus of the ovule and the endosperm may also take part in the formation of the seed-coat [1]). See moreover S. No. 404 and M. N. No. 25.

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[1]) For determining the part taken in the formation of the testa by the different parts of the ovule, a special investigation of the development is often needed. A large number of interesting facts concerning this subject has been accumulated by the following authors:

J. J. Attema, De zaadhuid der Angiospermae en Gymnospermae en hare ontwikkeling. (The seed-coat of Angio- and Gymnospermae and its development). Dissertation of the University at Groningen 1901 and C. van Wisselingh, Bijdragen tot de kennis van de zaadhuid. (Contributions to the knowledge of the seed-coat), in Pharmaceutisch Weekblad 1918—1924; in all sixteen contributions, 1c. the nucleus or kernel (nucleus). All parts enclosed within the seed-coat; the embryo is never wanting, but in addition the nucellus of the ovule and the endosperm may take part in its formation. See moreover S. No. 408.

S. No. 403. (cf. S. No. 402). The funicle may give rise to the following parts:
1a. aril (arillus). This term designates a more or less complete investment of the ripe seed. *Taxus baccata* (fleshy); *Nymphaea alba* membranaceous); *Salix spp.* (consisting of hairs).
1b. the strophiole (strophiola). This term designates a localized ontgrowth of the funicle. *Viola tricolor*; *Chelidonium majus*; *Colchicum autumnale.*

S. No. 404. (cf. S. No. 402). Concerning the testa or spermoderm the following subjects will be dealt with:
1a. layers of different consistency. See S. No. 405.
1b. parts of the outer surface. See S. No. 406.
1c. appendages of the surface. See S. No. 407.

S. No. 405. (cf S. No. 404). Layers of different consistency.

The testa is often thin and may be reduced in some cases even to a single cell-layer, as in *Orchideae;* but in other cases, there occurs a differentiation into several layers, somewhat corresponding to those which often occur in the wall of the pericarp (cf. S. No. 388) and here the following terms are used:
1a. the sarcotesta. A thick fleshy outer layer.
1b. the sclerotesta. A thick stony middle layer.
1c. the endotesta. A thin membranaceous inner layer. Examples of such differentiations are afforded by *Cycas; Ginkgo biloba; Trigonocarpus Parkinsoni.*

S. No. 406. (cf. S. No. 404). On the outer surface of the testa we may distinguish the following parts, most of them corresponding to parts of the ovule (cf. S. No. 358); these parts may have become invisible during the development of the seed, but in other cases they are clearly distinguishable:
1a. the hilus or hilum (hilus, hilum). The scar of the funicle which is always more or less visible and this of course does not yet exist in the ovule, or in the ripe seed as long as it remains united to the placenta.
1b. the micropyle (micropyle). It corresponds to the same part of the ovule (cf. S. No. 358), but has often become invisible to the naked eye in the ripe seed; it is easily distinguishable for

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concerning which it is a pity that they have been published in a non-botanical Dutch periodical. They fully deserve to be republished in translation in a more accessible place.

instance in seeds of *Phaseolus spp.* and *Cucurbita;* the radicle of the embryo is always to be found beneath it. The border of the micropyle may give rise to:

2a. the caruncle (caruncula). A more or less globular outgrowth on the top of the seed. *Euphorbia spp.; Ricinus communis.*

2b. the arillode (arillodium). This forms a complete investment of the seed. *Euonymus europaeus; Myristica fragans;* mace (macis) partly arillode and partly aril.

1c. the chalaza (chalaza). It corresponds to the same part of the ovule and is often irrecognizable from the outside. Examples of an outwardly visible chalaza in the ripe seed are afforded by *Vitis vinifera*; *Viola spp.*; *Phaseolus spp.*; *Prinus Amygdalus* and *Croton Tiglium.*

1d. the raphe (raphe). It corresponds to the same part of the ovule (cf. S. No. 358) and may be visible on the outside of the ripe seed. *Ricinus communis; Prunus Amygdalus.*

S. No. 407. (cf. S. No. 404). Appendages of the testa. The testa may exhibit various appendages of the surface, although in some cases parts of a different origin may be added to them; the most characteristic ones are the following:

1a. a coma (coma). This term designates a tuft of hairs. *Populus spp.*; *Epilobium angustifolium*; *Gossypium spp.*; *Eriodendron anfractuosum.*

1b. wings (ala). Seeds provided with them are called winged seeds. *Funkia ovata; Spergula arvensis; Pinaceae,* like *Pinus sylvestris,* the wing of this seed being however united in the course of development with a portion of the ovuliferous, afterwards seminiferous, scale [1]). (cf. S. No. 299).

S. No. 408. (cf. S. No. 402). Nucleus or kernel. Here we may distinguish the following parts:

1a. the embryo of the seed (embryo). The young plant which is never wanting, although in some cases, as in *Orchideae,* it may be very slightly developed. On the other hand it is of most common occurrence, that the whole nucleus consists of the embryo only. Examples are afforded by many seeds, containing a highly developed embryo, as in *Pisum sativum*; *Cucurbita spp.; Aesculus Hippocastanum*; *Castanea sativa* (*Castanea vesca*); *Quercus Robur*; but also by *Orchideae.* See moreover S. No. 409.

1b. albumen (albumen). This term designates parts containing as a rule nutritive material often in large quantity. These parts occur in addition to the embryo in the nucleus. See moreover S. No. 414. It may be formed by:

2a. the endosperm of the seed. (endospermium). This term designates a part of the albumen taking its origin in the embryo-sac and surrounding the embryo. Its formation may take place in the following ways:

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[1]) Engler u. Prantl. Nat. Pflanz. Fam. II Ed. 13 Band 1926. p. 297.

3a. it is the adult state of the so called endosperm of the ovule, already mentioned in S. No. 359, as corresponding to a female prothallium and already existing before fertilization; it is formed by means of simultaneous cell division. See S. No. 511. *Pinus Pinea; Ginkgo biloba; Cycas.*

3b. it is formed in the embryo-sac after fertilization and its formation may be due to one of the following modes of the development:

4a. successive cell division. See S. No. 511. This takes place in narrow embryo-sacs, as in *Monotropa* and *Aristolochiaceae.* In some cases however, after the first two daughter-cells have been formed, the endosperm arises by subsequent divisions of only one of them, being the upper one, as in *Viscum, Melampyrum* or *Thesium;* or the lower one, as in *Loranthus, Vaccinium, Verbena* or *Orobanche.*

4b, simultaneous cell division. See S. No. 511. This is the mode of formation, occurring in the large majority of *Angiospermae,* exhibiting an endosperm. *Fritillaria imperialis; Cocos nucifera; Strychnos Nux vomica; Coffea arabica.*

See moreover S. No. 415.

2b. the perisperm (perispermium). This term designates a storage tissue, arising from the nucellus of the ovule, surrounding the embryo-sac. It is mostly wanting, (cf. S. No. 401) but it may also occur together with the endosperm and surround it.

Examples of seeds exhibiting a nucleus, which for the major part consists of perisperm are afforded by: *Piper nigrum* and *Piper Cubeba.*

S. No. 409. (cf. S. No. 408). Concerning the embryo of the seed the following subjects will be dealt with:

1a. monembryony and polyembryony. See S. No. 410.
1b. segmentation of the embryo. See S. No. 411.
1c. the direction of the embryo in the seed. See S. No. 412.
1d. folding up of the embryo in the seed. See S. No. 413.

S. No. 410. (cf. S. No. 409). With respect to the number of embryo's in a single seed, we may distinguish:

1a. monembryony. There is but a single embryo in each seed. *Phaseolus vulgaris; Ricinus communis; Orchis.*

1b. polyembryony. There is more than one embryo in each seed and here we may distinguish the following cases:

2a. combination with sexual reproduction [1]).

3a. simple polyembryony. There is more than one zygote in each ovule.

3b. cleavage polyembryony. After fertilization the zygote splits up into more than one embryo.

Examples of the two foregoing cases are afforded by *Gymnospermae,* like *Pinus,* where both simple and cleavage polyembryony habitually occur together in each ovule, although ultimately in consequence of abortion only a single embryo is to be found in the ripe seeds.

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[1]) John T. Buchholz, Origin of cleavage polyembryony in Coniferae. Botan. Gaz. 81. 1926. p. 55.

2b. no combination with sexual reproduction.

3a. polyembryony in consequence of the formation of adventitious embryo's beyond the normal one. *Citrus spp.*, producing several embryo's in each ripe seed.

S. No. 411. (cf. S. No. 409). In the embryo we may distinguish the following parts:

1a. the root part.

2a. the radicle (radicula). This term designates the slightly developed first root, which afterwards grows out into the primary root of the plant.

2b. adventitious root buds. They appear sometimes and in small numbers. *Triticum vulgare.* See moreover S. No. 426.

2c. coleorhiza (coleorhiza). This term designates a kind of pouch, in which the radicle and possibly occurring adventitious root buds may be formed. *Gramineae.*

1b. the cormoid part of the embryo, which is segmented into:

2a. the hypocotyl (internodium hypocotylum) (cf. S. No. 189), bearing at its top the cotyledons, which are the cataphylls of the embryo (cf. S. No. 244) and occur in various numbers, a single one (*Monocotyledons*), two (*Dicotyledons* and many *Gymnosperms*), more than two, up to twelve or fourteen *(Pinus)*.

Moreover the following terms are in use for indicating parts of the embryo of a somewhat uncertain nature although more or less allied to cotyledons [1]).

3a. the scutellum (scutellum). This term designates a shield-like part of the embryo, turned towards and in contact with the endosperm. It is considered by some botanists as a cotyledon (Häckel), by others (van Tieghem, Klebs) as only a part of the cotyledon; the other portion being represented by the coleoptilum.

3b. the epiblast (epiblastus). This term designates a somewhat scaly part opposite the scutellum and considered by Häckel as a reduced second cotyledon. *Gramineae: Triticum vulgare,* and more strongly developed, in *Stipa* and *Zizania,* but in many cases wanting.

3c. the coleoptilum or coleophyllum (coleoptilum, coleophyllum). This term designates a phyllome, sheathing a plumule and considered by some as a cotyledon, by others as the upper half of it, and by others again, as a special prophyll of the plumule, repeated afterwards on the branches of the latter. *Gramineae.*

2b. plumule (plumula). This is a bud consisting of a small caulome, bearing one or more young leaves. Its basal internode immediately above the cotyledon or cotyledons is called epicotyl (internodium epicotylum) (cf. S. No. 189). The small leaves develop into the primary cauline leaves (folium caulinum primarium) of the plant; the number of cauline leaves in the seed is often two, (*Phaseolus multiflorus, Strychnos Nux vomica, Eugenia Jambolana*); sometimes more (*Prunus Amygdalus,* about eight); the coleoptilum, as has been mentioned above, is considered by some botanists as the first cauline leaf.

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[1]) Pax. Allg. Morphol. d. Pfl. Stuttgart 1890, p. 355.

S. No. 412. (cf. S. No. 409). According to the direction of the embryo with respect to the hilus of the seed, we may distinguish:
1a. the antitropous or antitropal (antitropus) embryo. The radicle is turned away from the hilus and the seed has been developed from an orthotropous ovule. *Juglans regia.*
1b. the radicle is turned towards the hilus.
2a. the homotropous or homotropal (homotropus) embryo. The radicle is turned almost directly towards the hilus and the seed has been developed from an anatropous ovule. *Umbelliferae.*
2b. the amphitropous or amphitropal (amphitropus) embryo. The radicle is turned towards a point in the vicinity of the hilus and the seed has been developed from a campylotropous or a camptotropous ovule. *Papilionaceae.*

The above terms are not of general importance, but useful if seeds are described of which the ovules in the ripe ovaries are unknown; there is no term for indicating embryos developed from a semi-anatropous ovule.

S. No. 413. (cf. S. No. 409). With respect to the manner in which the embryo is folded up within the ripe seed, we may distinguish the following cases:
1a. the embryo is folded together so that the radicle and the cotyledons are parallel to each other.
2a. the pleurorhizous or pleurorhizal embryo (pleurorhizus). The vernation of the cotyledons is plain and the radicle is turned against the edges on one side of the cotyledons; the transverse section of such an embryo may be indicated by the symbol: o =. *Arabis*; *Draba*; *Barbarea.*
2b. the notorrhizous or notorrhizal embryo (notorrhizus). The vernation of the cotyledons is plain and the radicle is turned against the abaxial side of one of the cotyledons; the transverse section of such an embryo may be indicated by the symbol: o ‖. *Sisymbrium.*
2c. the orthoploceous or orthoploceal embryo (orthoploceus). Both cotyledons are doubled up along the midrib towards one side so that the vernation of the outer one is conduplicate, whilst for the vernation of the inner one no special term exists, and the radicle lies within the folded cotyledons; the transverse section of such an embryo may be indicated by the symbol: o >>. *Brassica; Raphanus.*
1b. The embryo is folded together so that the radicle and the cotyledons are at a right angle to each other.

2a. the spirolobous or spirolobal embryo (spirolobus). The cotyledons are spirally rolled up, so that the outer cotyledon shows a circinate and the inner one a retrorsum circinate vernation; the transverse section of such an embryo may be indicated by the symbol: o ‖ ‖. *Bunias.*

2b. the diplecolobous or diplecolobal embryo (diplecolobus). The cotyledons are folded zigzag, showing a vernation for which no special term exists; the transverse section of such an embryo may be indicated by the symbol: o ‖ ‖ ‖ ‖. *Senebiera; Subularia; Acer Pseudo-Platanus.*

S. No. 414. (cf. S. No. 408). According to the presence or absence of an albumen, we may distinguish:
1a. the albuminous seed (Semen albuminosum). Albumen present. *Gramineae; Piper cubeba.*
1b. the exalbuminous seed (Semen exalbuminosum). *Phaseolus; Cruciferae.*

S. No. 415. (cf. S. No. 408). Concerning the endosperm the following subjects will be dealt with:
1a. shape of the endosperm. See S. No. 416.
1b. consistency of the endosperm. See S. No. 417.

S. No. 416. (cf. S. No. 415). Shape of the endosperm. Here we may distinguish the following terms:
1a. the orthospermous endosperm (orthospermus). The endosperm is flat at the side turned towards the raphe. *Umbelliferae: Orthospermeae,* such as *Pimpinella Anisum* and *Foeniculum vulgare.*
1b. the coelospermous endosperm (coelospermus). The endosperm is incurved at the side turned towards the raphe. *Umbelliferae*: *Coelospermeae,* such as *Coriandrum sativum.*
1c. the campylospermous endosperm (campylospermus). The endosperm is curved at the margins at the side turned towards the raphe, so as to form a longitudinal furrow. *Umbelliferae: Campylospermeae,* such as *Conium maculatum.*
1d. the ruminated endosperm (endospermium ruminatum). The endosperm shows numerous narrow and deep incisions of its outer surface, filled up with more darkly coloured layers, which are outgrowths of the testa and give the endosperm a veined appearance. *Anonaceae; Myristica fragans.*

S. No. 417. (cf. S. No. 415). Consistency of the endosperm. With respect to this character we may distinguish:
1a. farinose (farinosus). Mealy. *Secale cereale; Zea Mays,* in part.
1b. carnose (carnosus). Fleshy, rich in albuminous substances. *Ricinus communis.*
1c. stony (scleroïdus). Very hard, rich in cell-wall substances.

Phoenix dactylifera; Phytelephas macrocarpa and many other *Palmae.*
1d. horny (corneus). Corneous or cartilaginous. *Colchicum autumnale; Strychnos Nux vomica.*

S. No. 418. (cf. S. No. 400). Concerning the development of the seedling from the seed the following subjects will be dealt with:
1a. meaning of the term seedling. See S. No. 419.
1b. perforation of the coleorhiza. See S. No. 420.
1c. functions of cotyledons. See S. No. 421.
1d. epigaeous and hypogaeous cotyledons. See S. No. 422.
1e. functions of endosperm. See S. No. 423.

S. No. 419. (cf. S. No. 418). Seedling or germ plant (plantula). This term designates the young plant, arising from a seed and as far as it can be developed from the nutritive material accumulated in the seed. Its grade of possible development can strictly speaking only be ascertained by special experiments. Nevertheless for many seeds its limits may be determined with sufficient certainty in the practice of plant breeding.

S. No. 420. (cf. S. No. 418). Perforation of the coleorhiza. Where the coleorhiza occurs, covering the radicle or adventitious young roots (cf. S. No. 411), it is perforated during germination by the tip of the young root and remains in the shape of a collar at the base of the young root. *Gramineae.*

S. No. 421. (cf. S. No. 418). Functions of cotyledons.
Various functions, corresponding to certain metamorphoses, occur among cotyledons and although combined or transitional states are by no means rare, yet some typical cases may be distinguished, which during the germination of the seed plant may be observed. They are:
1a. storage of reserve materials (cf. S. No. 238), which are consumed during germination in the formation of the seedling. *Phaseolus multiflorus; Tropaeolum vulgare.*
1b. suction of reserve materials (cf. S. No. 239), which during germination pass through the cotyledons towards the seedplant. *Phoenix dactylifera* and many other *Palms; Trapa natans; Rhizophora Mangle* [1]).
1c. they grow out into the first foliage leaves of the plant, but these mostly exhibit smaller dimensions and simpler shapes than the ordinary foliage leaves of the same plant. *Cucurbita Pepo; Fagus sylvatica; Allium Cepa; Welwitschia mirabilis; Lepidium sativum, Acer Pseudo-Platanus; Pinus sylvestris.*
1d. a single cotyledon grows out into the only and large foliage leaf which the plant produces. *Streptocarpus Rexii* and some other species of the same genus.

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[1]) Warming. Tropische Fragmente 2. Engler's Jahrb. IV, 1883, p. 519.

S. No. 422. (cf. S. No. 418). The cotyledons of seeds germinating in the earth, may remain there or may be lifted up into the air and thus we may distinguish:
1a. hypogaeous cotyledons (hypogeus). They remain in the soil. *Phaseolus multiflorus*; *Quercus Robur*; *Aesculus glabra* (A. *rubicunda*).
1b. epigaeous cotyledons (epigeus). By growth of the hypocotyl they are lifted up into the air. *Phaseolus vulgaris; Ricinus communis; Fagus sylvatica; Cruciferae; Streptocarpus Rexii.*

S. No. 423. (cf. S. No. 418). Functions of the endosperm of the seed. Here we may distinguish:
1a. storage of reserve materials, which are consumed during germination in the formation of the seedling. *Gramineae* and the large majority of albuminous seeds.
1b. suction of reserve materials, which during germination pass through the endosperm towards the seedling. *Rhizophora mangle.*

§ 3. Root (radix). Confer for the meaning of this term. S. No. 73.

A. General description.

S. No. 424. Concerning the description of the root the following subjects will be dealt with:
1a. presence and absence of roots. See S. No. 425.
1b. origin of roots. See S. No. 426.
1c. differentiation of the root. See S. No. 427.

S. No. 425. (cf. S. No. 424). Presence and absence of roots. True roots are wanting not only in thallomes, but also in *Musci*, although the latter are provided with well developed cormi. In the higher plants *Pteridophyta* and *Spermatophyta* roots appear in the great majority of cases, although exceptions do occur; thus for instance roots are wanting in: *Psilotum*; *Corallorhiza innata*; *Salvinia*; *Wolffia arrhiza*; *Utricularia vulgaris*; *Ceratophyllum*; *Tillandsia usneoides*. See moreover M. N. No. 26.

S. No. 426. (cf. S. No. 424). Origin of roots. In this respect we may distinguish:
1a. the primary root (radix primaria). This term designates a root forming a prolongation of the primary stem and it is clear that a plant can possess not more than a single primary root. In *Gymno-* and *Angiosperms* it is the grown out radicle of the seed, often producing a large number of lateral roots of several orders. In many annuals, such as *Vicia Faba, Senecio vulgaris* and *Geranium Robertianum,* the primary root system is not only the essential but also the only root system of the plant.

In *Gramineae* 1) the primary root does not disappear as was formerly supposed, but grows out into a strongly branched root system, spreading through a relatively considerable volume of soil; the depth to which these root systems penetrate into the earth is very different, for instance: *Festuca elatior* 8 cm; *Avena* 20—40 cm; *Triticum* 50—70 cm; *Secale* 60 cm.

In our trees and shrubs belonging to *Gymno-* and *Angiosperms* the primary root certainly forms a considerable part of the root system, but in how far roots of other origin may cooperate in its formation remains to be investigated.

In plants exhibiting rhizomes which always decay at their base the primary root is of course sooner or later lost. Examples are afforded by many *Pteridophyta, Gymno-* and *Angiospermae,* whose primary root exists only during the germinating stages and some time afterwards.

1b. adventitious or secondary roots (radix adventitia). This term designates all roots not being a primary root or one of its lateral branches of any order. In all cases where the primary root soon dies, the essential parts of the root system are formed by adventitious roots, as in *Ferns; Lycopodium; Selaginella; Polygonatum officinale* and many other plants provided with cormoid rhizomes.

Thus there is a contrast between the occurrence of adventitious cormi and adventitious roots. The former are of course by no means rare, but they do not play a part of general importance in the formation of cormoid systems. This however often occurs in root systems, where in many cases adventitious roots are practically the only ones performing the functions for which roots are necessary.

Among adventitious roots we may distinguish:

2a. adventitious roots growing from rhizomes representing only a caulome (cf. S. No. 187). The existence and character of spatial relations between these roots and the phyllotaxy of the rhizome ought to be studied for every case. *Aspidium Filix mas.*

2b. adventitious roots growing from cormoid rhizomes. (cf. S. No. 277). The existence and character of spatial relations between these roots and the phyllotaxy of the rhizome ought to be studied for every case. *Equisetum arvense; Acorus Calamus.*

2c. adventitious roots arising without any distinguishable spatial relation with the phyllotaxy of the cormus which produces them, mostly from a pluri- or even multicellular area. Sometimes only a single root has such an origin, for instance in: *Orchis Morio,* root tuber arising within a lateral cormoid bud; this tuber representing a single root which may become branched in other species, as in *O. maculata.* In many other cases however a large number of roots is formed together in one area. Thus in many cormoid bulbs, like *Hyacinthus orientalis,* numerous adventitious roots are produced

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1) K. Zijlstra. De hoofdwortel van eenige graansoorten. Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations No. XXVI the Hague, 1922.

together from the inferior surface of the disc. In *Palms* the inferior surface of the stem produces innumerable relatively thin roots, strongly branching into root systems. Other examples are afforded by the spiny roots or root-thorns, appearing for instance in *Acanthorhiza aculeata* at the base of the stem between the scars of fallen leaves and having the shape of strongly branched spines; further by the root-thorns of *Myrmecodia.*

3a. primordial adventitious roots or germ adventitious roots[1]). These terms designate adventitious roots of which the buds appear already in the embryo, not as parts of the radicle, but formed separately and situated in its neighbourhood above it, just where stem and root meet. They may grow out into strongly branched root systems, exhibiting a peculiar anatomical structure[2]), different from that of crown roots, borne by the same plant. *Avena* (3—4; mostly 3). *Triticum:* summer-wheat (2—7; mostly 5); winter-wheat (5). *Secale cereale:* winter-rye (3—9). *Hordeum:* summer-barley (4, 5 and 6); winter-barley (5).

3b. crown roots. This term designates adventitious roots formed in a later developmental stage of the plant arising from nodes situated more or less at the base of the stem. These roots often appear in large numbers, even more than one hundred at each node and they may grow out into richly branched root systems; they exhibit a peculiar anatomical structure differing from that of the primordial adventitious roots in the same plant[2]). *Hordeum distichum*; *Avena*; *Triticum; Secale cereale.*

2d. roots arising from dormant root-buds. They are of exceedingly common occurrence and many examples are afforded by plants which may be propagated by cuttings. *Salix spp;* buds of roots, beneath axillary cormoid buds, coming into action in cuttings.

2e. adventitious roots arising under certain conditions from single mature cells. Examples are afforded by many foliage leaves when cut off and placed with their petioles in earth or water, for instance leaves of *Begonia Rex.*

In making Pen-portraits of the roots of a plant, it is obviously necessary to begin always by making a complete determination of the several kinds of roots which it may exhibit in the several phases of its existence, and in some cases it will be necessary to make special experiments for this purpose. It will be found that relatively few plants show like *Vicia Faba,* only a single kind of root.

See moreover M. N. No. 26.

S. No. 427. (cf. S. No. 424). Concerning the differentiation of the root the following subjects will be dealt with:

1a. root-individual. See S. No. 428.

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[1]) Zijlstra. l.c.

[2]) M. A. J. Goedewaagen en K. Zijlstra. De inwendige bouw der wortels van gerst (Hordeum distichum). Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations No. XXX, the Hague, 1926.

1b. periodic and annual roots. See S. No. 429.
1c. succession of roots. See S. No. 430.
1d. succession of roots formula. See S. No. 431.
1e. parts of the root. See S. No. 432.
1f. shape of root-body. See S. No. 433.

S. No. 428. (cf. S. No. 427). Root-individual. Although the organography of the root is very simple, compared with that of the cormus, and the number of metamorphoses is relatively very limited, nevertheless the same general phenomena may be observed which appear in the development of the cormus and for particulars on this point the reader is referred to S. No. 242, dealing with the cormus-individual. Thus we may distinguish root-individuals as products of a single vegetative cone. The term root systems may be used as a counterpart to that of cormoid systems and designates also every branched root, consisting of two or more root-individuals.

As in cormoid systems there may appear here also essential and non-essential root-individuals, and if there are two or more kinds of essential root-individuals the order of sequence of the root-individual is also called a simple alternation of generations.

S. No. 429. (cf. S. No. 427). Periodic and annual roots. It seems highly probable that equivalents of those phenomena, which in cormi commonly occur and have a certain importance, will often appear in roots, although the want of phyllomes and the several regions to which phyllomes may give rise, certainly must be prejudicial to be distinguishing of both periodic as well as annual roots. It is to be hoped that the attention of future phytographers will be directed towards these subjects more than it has been customary hitherto.

S. No. 430. (cf. S. No. 427). Succession of roots. As in cormi we may distinguish according to the number of essential individuals:

1a. uniaxial roots. *Dendrobium nobile,* aerial roots; *Lemna monorhiza; Hydrocharis Morsus Ranae.*

1b. biaxial, triaxial etc. roots. *Scindapsus pertusus,* aerial root, branching at its apex when it penetrates into the soil. *Philodendron melanochrysum* [1]). *Pandanus spp.,* pneumatophores, producing nutritive roots [2]). More detailed examples of complex cases like the primary well developed roots of trees and shrubs can be given as soon as careful pen-portraits are available.

S. No. 431. (cf. S. No. 427). Succession of roots formula. There is no doubt that such formulae in every respect comparable with succession of cormi formulae (cf. S. No. 252) can be constructed. Nevertheless it would be premature to give rules here for their construction, because no pen-portraits are available of the more complex and most interesting root-systems of well developed primary roots, like those of many trees and shrubs. The construction of some pen-portraits however is by no means easy, because the materials for making them are often far from accessible. Thus the construction of succession of roots formulae may be left to future phytographers, well versed in the method of pen-portraits. These formulae in substance ought to conform to the succession of cormi formulae worked out in S. No. 252 but the choice of the necessary abbreviations is better postponed till the morphological facts have been duly registered. For the rest the reader is referred to Morphological Note No. 18.

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[1]) F. A. F. C. Went, Ueber Haft- und Nährwurzein bei Kletterpflanzen und Epiphyten. Ann. du Jardin Botan. Buitenzorg. Vol. XII 1895, p. 1.

[2]) J. C. Schoute, Die Pneumatophoren von Pandanus. Ann. du Jardin Botan. Buitenzorg. 2e. Sér. Suppl. III. 1910, p. 216.

S. No. 432. (cf. S. No. 427). In the root we may distinguish the following parts[1]:
1a. the body of the root (corpus). The principal, often more or less thickened part of the root.
1b. the apex (apex). The thin top of the root, often greatly elongated and mostly turned downwards.
1c. the root-hairs (pilus radicalis). They are outgrowths of epidermal cells, appearing in the vicinity of the growing apex and remaining till the epidermis is thrown off by the development of the primary cork layer or of secondary tissues. Thus roots, becoming very long without losing their epidermis, may remain covered with root-hairs over a considerable length, for instance the primary root of *Gramineae*[2], over half a meter and more (cf. S. No. 426). In several text-books it is asserted that root-hairs are wanting, for instance in many *Conifers*, such as *Abies* and *Pinus*, further in *Crocus*, also in aquatic plants, such as *Azolla, Lemna, Butomus, Stratiotes, Hippuris* and *Menyanthes*. It is certain that *Azolla* and *Lemna* do not possess root-hairs, but for some other cases renewed investigations might be useful; they are also wanting in parasitic plants, such as *Cuscuta*. They strongly develop in moist air and in water. The number of root-

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[1] In older works we find among the terms for parts of the roots also that of collum, neck, foot (Oudemans), collet (De Candolle), crown of the root, Fundus plantae or Nodus vitalis, all these terms having been used for designating the plane of separation between upward and downward growth. These terms however must be considered as obsolete, although in former times they may have possessed a great importance. See Bischoff, Handbuch der botanischen Terminologie Bd. I 1833, p. 126, where most of the terms mentioned above and the conception of these terms as designating a plane have been mentioned. See moreover Sachs, Geschichte der Botanik, München, 1875, p. 50, where interesting historical data concerning the extraordinary importance attached in former times to this plane are to be found.

[2] K. Zijlstra, De hoofdwortel van eenige graansoorten, l.c. It is often said, that in water cultures of land plants, possessing them when growing in earth, *(Pisum, Phaseolus* and *Zea)* root-hairs are wanting, but this is a mistake and it is easy to ascertain by more accurate observation that they show a strong development. Verbal communication of Dr. Zijlstra.

hairs is very large, for instance more than two hundred on each square mm of *Pisum.*

1d. the calyptra or root-cap (calyptra). This is a special organ covering the apex of roots. It is very characteristic of the root and of general occurrence. Nevertheless it may be wanting and examples of this kind are afforded by the primary roots in seedlings of *Trapa natans* and *Cuscuta,* also by the small and often transitory roots developing in the buds of *Aesculus Hippocastanum.* In other cases a calyptra appears which is thrown off soon afterwards, as in *Azolla, Hydrocharis, Pistia* and *Bromeliaceae.* A well developed calyptra can often be distinguished only in median sections of the apex *(Zea Mays),* but in other cases, such as *Pandanus* and *Scindapsus,* it is easily observed from the outside as a cap covering the apex. In some cases the calyptra is replaced by a so called root-pocket, which in reality does not belong to the root, but is an outgrowth of another part on which the root is placed; examples are afforded by spp. of *Lemna* and *Azolla.*

S. No. 433. (cf. S. No. 427). Shape of root-body. With respect to this character we may distinguish:

1a. the tap-root or conical root (fusiformis). *Daucus carota.*

1b. the napiform or turnip-shaped root (napiformis). Root-body very thick, although the apex may be very thin and elongated. To this thick root-body are often added one or more thick internodes of the stem. *Raphanus sativus; Brassica campestris (B. rapa).*

1c. the thread-shaped root (filiformis). Very thin and long. *Spergula arvensis; Gramineae,* primary root.

2a. the fibrous root (fibrosus). This term is used for adventitious roots with a thread-shaped body; they are often very numerous, and may become strongly branched. *Gramineae,* primordial or germ adventitious roots and crown roots.

B. Special kinds of roots and specially differentiated parts of roots.

S. No. 434. Concerning special kinds of roots the following subjects will be dealt with:

1a. aerial roots. See S. No. 435.
1b. pneumatophores. See S. No. 436.
1c. stilt-roots or prop-roots. See S. No. 437.
1d. root-tendrils. See S. No. 438.
1e. root-thorns. See S. No. 439.
1f. root-hapterae. See S. No. 440.
1g. root-haustoria. See S. No. 441.
1h. roots capable of carbon assimilation. See S. No. 442.
1i. floating-roots. See S. No. 443.
1j. root-tubers. See S. No. 444.
1k. root-tubercles of Leguminosae. See S. No. 445.
1l. buttress-roots or flange-roots. See S. No. 446.

S. No. 435. (cf. S. No. 434). Aerial roots (aereus). They are adventitious roots arising from stems or branches, often at a considerable height from the ground; they may become very long and thick; they are mostly unbranched while they grow in the air, sooner or later they may become attached to solid bodies or penetrate with their apex into the soil and in the latter case they produce an often profusely branched root system. They are often provided with a velamen (see S. No. 725). The following examples may be cited: *Lycopodium clavatum; Dendrobium nobile; Monstera; Scindapsus; Hemitelia crenulata Mett* [1]; the genus *Ficus* affords many of the most interesting and curious examples, such as *Ficus Benjamina* and *F. Bengalensis* (Waringin) producing from the under side of its branches column-roots or root-supports, so that a single tree, by means of its stem branches may extend like a wood over a colossal area; several other species of *Ficus* have been called strangling fig trees, and interesting descriptions and plates concerning these plants are to be found in a paper by Trelease [2].

S. No. 436. (cf. S. No. 434). Pneumatophores [3], respiratory or aerating roots (pneumatophorus). They are adventitious, often lateral roots, bearing one or more light coloured prominent spots, consisting of a spongy tissue, the pneumathodes [4], (pneumathodium), possessing numerous radially arranged aerating intercellular passages. *Avicennia; Sonneratia; Laguncularia; Cymbidium; Cocos nucifera.*

S. No. 437. (cf. S. No. 434). Stilt-roots or prop-roots. Oblique adventitious roots bearing a stem and often occurring in the Mangrove. *Rhizophora mucronata* Lam; *Pandanus.*

S. No. 438. (cf. S. No. 434). Root-tendrils. They are adventitious roots performing the functions of tendrils (cf. S. No. 75). *Vanilla; Melastomataceae (Medinilla, Dissochaeta); Loranthaceae (Struthanthus, Phtirusa).*

S. No. 439. (cf. S. No. 434). Root-thorns or spiny roots. (cf. S. No. 75). They are adventitious roots metamorphosed into spines. *Acanthorhiza aculeata*; *Myrmecodia.*

S. No. 440. (cf. S. No. 434). Root-hapterae or anchoring roots. They are adventitious roots metamorphosed into hapterae

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[1] J. C. Schoute, Eine neue Art der Stammesbildung im Pflanzenreich. Ann. d. Jard. Bot. de Buitenzorg. Vol. 20, 1906, p. 198—207.

[2] W. Trelease, Illustrations of a "strangling" Fig tree, from the sixteenth annual report of the Missouri botanical garden. 1905. p. 161.

[3] G. Karsten, Ueber die Mangrove-Vegetation im Malayischen Archipel, Bibl. Bot. Heft 22, 1891.

[4] L. Jost, Ein Beitrag zur Kenntniss der Athmungsorgane der Pflanzen, Bot. Ztg, 45, 1887.

(cf. S. No. 75). *Hedera Helix*; *Philodendron melanochrysum*[1]; *Podostemaceae,* certain specially differentiated roots.

S. No. 441. (cf. S. No. 434). Root-haustoria or root-suckers (haustorium). They are adventitious roots or appendages of the surface belonging to them, metamorphosed into haustoria (cf. S. No. 75). *Cuscuta; Viscum album; Orobanche; Euphrasia* and *Thesium* (appendages of the surface).

S. No. 442. (cf. S. No. 434). Roots metamorphosed into organs of carbon assimilation (cf. S. No. 75). They are adventitious roots coloured green and often flattened. *Taeniophyllum; Polyrrhiza; Angraecum; Podostemaceae; Mirabilis* and *Menyanthes,* roots becoming green when exposed to light.

S. No. 443. (cf. S. No. 434). Floating-roots. They are adventitious roots provided with a strongly developed aërenchyma. *Jussiea,* roots at the nodes of the stem.

S. No. 444. (cf. S. No. 434). Root-tubers. They are adventitious roots, metamorphosed into tubers, containing reserve materials and dying off when these are used up. *Orchis* and other *Orchideae, Ficaria ranunculoides, Ranunculus millefoliatus, Valeriana tuberosa,* all provided with cormoid buds; *Dahlia, Spiranthes*; *Ranunculus illyricus, Ranunculus hybridus,* not themselves provided with cormoid buds, but destined to yield their reserve materials to cormoid buds, developed on the same caulome which produced the root-tuber, but at a small distance from it in an apical direction. Confer also S. No. 117.

S. No. 445. (cf. S. No. 434). Root-tubercles of Leguminosae. They are roots metamorphosed into organs containing Bacteria[2].

S. No. 446. (cf. S. No. 434). Buttress-roots or flange roots. They are flat, flange-like roots forming buttresses at the base of trees; these roots are grown together with the basal part of the tree and show a formation of secondary tissues, chiefly secondary xylem, only at their upper side; their dimensions may become colossal and their height may amount, for instance to six meters. Examples are afforded by: spp. of *Sterculia*[3] and some of *Ficus.*

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[1] Went. l.c.

[2] M. W. Beyerinck. Die Bacterien der Papilionaceen-Knöllchen, Bot. Zeit. Jahrg. 48. 1888, p. 726.

[3] R. R. Gates, A botanist in the Amazon valley, London 1927, p. 94.

§ 4. Appendages of the external surface and the surfaces of internal cavities (organum accessorium). Confer for the meaning of this term. S. No. 73.

S. No. 447. Concerning these appendages the following subjects will be dealt with:
1a. characters of the internal cavities, containing the appendages. See S. No. 448.
1b. description of appendages. See S. No. 449.
1c. special kinds of appendages. See S. No. 450.

S. No. 448. (cf. S. No. 447). The internal cavities mentioned above may be of the following kinds:
1a. cavities caused by an irregular growth of the surface leading to the formation of a considerable depression. *Azolla,* aerial lobe of leaf; *Nerium Oleander*, leaf (cavities with stomata at the bottom).
1b. cavities arising by the folding of certain parts. The internal cavities of fruits.
1c. intercellular cavities or passages. Parts of many aquatic plants; *Aspidium Filix mas,* base of petiole.

S. No. 449. (cf. S. No. 447). Description of appendages.[1] They are generally relatively small and of simple shapes, being more or less cylindrical or flat or even somewhat leaf-like, moreover they may be unbranched or branched. A particular set of terms for describing appendages does not exist. The only terms of such a kind are:
1a. capitate appendages, exhibiting:
  2a. the head. A thicker upper part.
  2b. the stalk. A thinner, lower part of different length, sometimes very small and even wanting.
1b. glandular appendages. They are mostly capitate appendages, whose heads excrete substances of various kinds, often etherial oils, sometimes gums or a mixture of both.

S. No. 450. (cf. S. No. 447). Special kinds of appendages. Here we may distinguish:
1a. papillae (papilla). Surfaces covered with them are called papillose (papillosus). They are short and mostly conical, never branched. They are often the cause of a velvety appearance of the surface.
  2a. ordinary papillae. *Viola tricolor,* petal.
  2b. stigmatic papillae. They are mostly somewhat elongated. *Crocus vernus.*
  2c. capitate papillae. *Mesembryanthemum crystallinum,* leaf.

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[1] If appendages are absent, the surface is of course called glabrous or smooth (glaber), but this is not a botanical term.

1b. hairs (pilus). Surfaces covered with them are called pilose (pilosus). They are longer than papillae, often reaching considerable dimensions, decidedly cylindrical, unbranched up to richly branched and among them we may distinguish:

2a. ordinary hairs. They correspond to the above definition, without showing further particulars. With respect to the character of these hairs, the hairy surface may be distinguished by the following terms:

3a. pubescent or downy (pubescens). Covered with fine, recumbent, short hairs. *Ranunculus acris,* leaves.

3b. shaggy (villosus). Covered with long hairs. *Fragaria vesca,* leaf.

3c. hirsute (hirsutus). Covered with stiffish beard-like hairs. *Hieracium pilosella.*

3d. woolly (lanatus). Covered with hairs resembling wool. *Stachys lanata,* leaf.

3e. tomentose (tomentosus). Covered with hairs, so close as scarcely to be separately discernible. *Verbascum Thapsus* and *Populus alba,* leaves.

2b. balance hairs. They are T-shaped, exhibiting a more or less developed stalk and a very long transverse beam. *Artemisia Absynthium,* leaf; *Sapotaceae.*

2c. stellate hairs. They are provided with a relatively large number of radiating and more or less equal branches. *Deutzia scabra; Althaea officinalis.*

2d. clinging hairs. They exhibit more or less curved, hooked or anchor-like shapes. *Rubia tinctorum,* stem.

2e. collecting hairs or brush-like hairs of style, pushing pollen out of anthers. They are short, rather slender, stiff and pointed hairs. *Compositae.*

2f. stings or stinging hairs (stimulus). They are tapering towards the top and terminate somewhat like capitate hairs in a very small head, the neck of which is easily broken, so that the poisonous contents of the hair are set free. *Urtica urens, Laportea gigas, Loasaceae,* leaves.

2g. capitate hairs (cf. S. No. 449).

3a. not glandular or ordinary capitate hairs. *Datura Stramonium,* leaf.

3b. glandular capitate hairs. *Compositae, Labiatae* (cf. S. No. 449). See further S. No. 738.

2h. root-hairs. They are hairs performing functions of attachment to the substrate and perhaps suction of nutritive materials, both functions being often combined together; they may be short, even resembling papillae, their length varying however with the character of the surrounding medium; they are mostly unbranched. *Pteridophyta, Gymno-* and *Angiospermae,* roots.

If hairs performing the above functions appear on plants not possessing true roots, the following terms are used:

3a. rhizoids. They may have the same shapes as common root hairs, but in other cases they are strongly branched and may extend over a large area. *Aspidium Filix mas,* gametophyte; *Psilotum,* rhizome; *Rhynia,* rhizome; *Marchantia polymorpha,* thallus; *Musci,* protonema with strongly branched rhizoids.

3b. rhizines. They are unbranched and may be somewhat flattened. *Lichens.*

1c. haptere-appendages. (cf. S. No. 75). Certain root hairs, belonging to specially differentiated roots[1]). *Podostemaceae.* See moreover S. No. 738.

1d. haustorial appendages. (cf. S. No. 75). Small appendages of mycelia penetrating into cells of the host plant. *Phytophthora infestans.*

1e. epidermal emissaries or trichome emissaries. (see S. No. 647). *Phaseolus multiflorus,* leaf.

1f. bristles (seta). They are firm and more or less hard and thick hairs. *Papaver Rhoeas* and *Boragineae,* green parts.

2a. awn or beard (arista). These terms designate a stiff bristle, arising singly from the adaxial side of a bract. *Gramineae,* on *glumae* and *paleae,* species possessing them being called bearded. *Secale cereale; Triticum.*

1g. prickles (aculeus). They are hard, often somewhat woody, more or less conical and sharp, like spines. *Rosa pomifera* and *Rubus* spp., stem; *Ilex Aquifolium,* leaf.

1h. scurves or scales (lepis). They are flat trichomes, sometimes provided with a short stalk.

2a. ordinary scurves. Mostly circular or polygonal. *Croton eluteria,* leaf.

2b. ramenta (ramentum). Elongated and sometimes rather large. *Ferns; Davallia dissecta,* stalked.

1i. paraphylls (paraphyllium). They are cylindrical or somewhat leaf-like, more or less branched, borne by the stem of *Musci* between the leaves, but not being parts of the latter, so that they may not be considered as stipules. *Climacium dendroides.*

1j. indusia of certain sori. They may surround the sori, somewhat as a wall, such as the sori of antheridia in *Dictyota,* but in most cases they more or less cover the group of organs forming the sorus, exhibiting peltate, reniform *(Aspidium)* or lip-like *(Scolopendrium)* shapes.

1k. paraphyses. They are sterile hairs, occurring in fructifications between reproductive organs, either sexual or asexual; they may be unbranched or branched. *Fucus,* conceptacles, playing part in the formation of the hymenium, unbranched hairs between the sexual organs, some protruding in tufts from the mouth of the conceptacles; *Hymenomycetes* and *Ascomycetes,* playing part in the formation of the hymenia, unbranched hairs between the basidia or asci; *Aspidium Filix mas,* playing part in the formation of the sorus, branched hairs between the sporangia; *Marchantia polymorpha,* gemma-cups, playing part in the formation of the hymenium, unbranched hairs between the gemmae; *Musci,* playing part in the formation of the cormoid receptacle, branched hairs between the antheridia and archegonia.

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[1]) Warming in Engler u. Prantl. III, 2a, p. 3.

Special kinds of paraphyses are:

2a. cystids. They are unbranched, larger than the ordinary paraphyses, occurring together with them, globular or club-shaped. *Russula rubra,* hymenium.

2b. periphyses. They are ordinary paraphyses, surrounding the groups of reproductive organs and not placed between them. *Podospora fimiseda,* hymenium of perithecium.

SECTION III. ANATOMY.

CHAPTER I. INTRODUCTION.

S. No. 451. In this introduction the following subjects will be dealt with:
1a. the importance of cellular structure. See S. No. 452.
1b. unicellular and pluricellular organisms. See S. No. 453.
1c. tissues. See S. No. 454.
1d. the division of anatomy into cytology and histology. See S. No. 455.

S. No. 452. (cf. S. No. 451). The study of Anatomy is based on the fact that in the internal structure of all vegetable organisms the existence of the cell (cellula) is a predominant feature. Cell is the unit, constituting all organisms whether alone or in conjunction with other cells.

The chief and often the only constituent part of the cell is a living organism which may be naked, but which in the majority of cases is invested with a protective layer of non-living substance.

S. No. 453. (cf. S. No. 451). With respect to the number of cells we may distinguish:
1a. unicellular organisms. Consisting of a single cell. Many *Algae.*
1b. pluricellular organisms. Consisting of more than one, mostly of a large number of cells. All higher plants.

S. No. 454. (cf. S. No. 451). Tissues. This is a comprehensive term, designating groups of cellular elements, considered as belonging together by their similarity and often also by their mutual arrangement. They obviously only occur in pluricellular organisms.

S. No. 455. (cf. S. No. 451). The subject-matter dealt with in Anatomy may be divided as follows:
1a. Cytology. This division deals with the several parts constituting the cell. See § 1, S. No. 456.

1b. Histology. This division deals with the several kinds of cells arising from various combinations of cytological characters, and constituting tissues; it further deals with the tissues themselves. See § 2, S. No. 552, and moreover M. N. No. 27.

CHAPTER II. ANATOMICAL SYSTEM.

§ 1. Cytology (cf. S. No. 455).

S. No. 456. Concerning the cell the following subjects will be dealt with:
1a. cell wall and cell contents. See S. No. 457.
1b. the living organism being the principal constituent of the cell. See S. No. 458.
1c. the cell wall. See S. No. 515.
1d. turgor and plasmolysis. See S. No. 550.

S. No. 457. (cf. S. No. 456). Cell wall and cell contents. In cells which are invested with a protecting layer we may distinguish:
1a. the cell wall. This is the protecting layer of non-living substance.
1b. the cell contents. They consist originally always of the living organism which is the chief constituent of the cell, but after its death and disappearance the contents may consist of air, water or solid substances of the most various kinds.

S. No. 458. (cf. S. No. 456). The living organism being the principal constituent of the cell. Concerning the living organism the following subjects will be dealt with:
1a. the terms protoplasm and protoplast in their reciprocal relations. See S. No. 459.
1b. protoplasm. See S. No. 460.
1c. protoplast. See S. No. 461.
1d. cell reproduction. See S. No. 509.
1e. internal streaming movements of the protoplasm. See S. No. 514.

S. No. 459. (cf. S. No. 458). Protoplasm. This is a comprehensive term designating the various living substances which constitute the protoplast, considered from a chemical and physical point of view. See S. No. 460.

Protoplast. This term designates the living organism of one single cell, either in a naked state or inhabiting the cavity within the cell wall. See S. No. 461.

S. No. 460. (cf. S. No. 458). In the protoplasm we may distinguish:
1a. hyaloplasm or protoplasm proper, generally homogeneous and transparent.
1b. granular protoplasm. Hyaloplasm containing as inclusions:

2a. microsomes (microsoma), small particles of a different refractive index and therefore discernible in the living state: they are of various shape and character, and make the granular protoplasm less transparent. Their nature is in most cases uncertain, though they are of most general occurrence. In some cases they may represent small starch grains or oil drops.

2b. chondriosomes or mitochondria (chondriosoma, mitochondrium), spherical, rod-shaped, filiform, fusiform or dumb-bell shaped bodies, appearing in some cases after a special fixation and colouring treatment. Their nature is wholly uncertain; in some cases they probably represent small vacuoles or small plastids.

S. No. 461. Protoplast. (cf. S. No. 458). Concerning the protoplast the following subjects will be dealt with:
1a. cytoplasm or general cell-plasm. See S. No. 462.
1b. nucleus and centrosomes. See S. No. 470.
1c. plastids. See S. No. 487.
1d. vacuoles. See S. No. 498.

S. No. 462. Cytoplasm. (cf. S. No. 461). Concerning cytoplasm the following subjects will be dealt with:
1a. meaning of the term. See S. No. 463.
1b. the finer structure. See S. No. 464.
1c. the coarser structure, in walled cells. See S. No. 465.
1d. protoplasmic processes of the outer surface. See S. No. 466.

S. No. 463. (cf. S. No. 462). The term cytoplasm designates the main body of the protoplast, excluding nuclei with centrosomes, plastids and vacuoles [1]).

S. No. 464. (cf. S. No. 462). In the cytoplasm we may distinguish:
1a. the ectoplasm. The thin layer of hyaloplasm, covering the protoplast on the outside, and bordering on the cell wall or in the case of naked protoplasts on the surrounding medium.
1b. the tonoplast. Thin layers of hyaloplasm surrounding the vacuoles.
1c. the middle layer. The bulk of the cytoplasm between the ectoplasm and the tonoplasts, generally consisting of granular protoplasm and often showing movements; in this layer are contained the nucleus, plastids and adventitious vacuoles and sometimes protein crystals.

S. No. 465. (cf. S. No. 462). In cells having a cell wall and one or more very large vacuoles we may distinguish:
1a. the parietal cytoplasm. The layer of cytoplasm lining the cell wall and consisting of ectoplasm, middle layer and tonoplasts.

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[1]) This term is often used in a more general sense, as including all parts of the protoplast with exception of the nucleus. I think that the more restricted sense of this term, proposed in the text, is to be preferred.

1b. strings or bands of protoplasm. Traversing the vacuole, and attached either with both ends to the parietal cytoplasm or with one end to the latter and with the other to a part of the cytoplasm suspended in the vacuole; sometimes branched; consisting only of middle layer and tonoplasts.

S. No. 466. (cf. S. No. 462). Concerning protoplasmic processes and smaller protuberances of the surface the following subjects will be dealt with:
1a. cilia and flagella. See S. No. 467.
1b. eye spots. See S. No. 468.
1c. connecting threads or plasmodesms. See S. No. 469.

S. No. 467. (cf. S. No. 466). Cilia, flagella and undulating membranes. Confer S. No. 142.
Blepharoplasts are protoplasmic bodies, concerned with the formation of cilia. They occur especially in the mother-cells of spermatozoids (*Bryophyta, Pteridophyta* and some *Gymnospermae*) and moreover in other naked cells provided with cilia *(Thallophyta)*.

S. No. 468. (cf. S. No. 466). Eye spot (stigma). (cf. S. No. 142). This is often a slight protuberance and may contain:
1a. a layer of red or brown pigment, occurring in all cases.
1b. starch-grains on the outside of the pigment layer.
1c. a small lens on the outside of the pigment layer. An example of this is afforded by *Pouchetia cornuta.*

S. No. 469. (cf. S. No. 466). Connecting threads or plasmodesms. This term designates fine cytoplasmic filaments uniting protoplasts separated by cell walls and either confined to the closing membranes of pits (see S. No. 540) or penetrating the whole thickness of the cell wall (endosperm of *Strychnos nux vomica)*.

S. No. 470. (cf. S. No. 461). Cell nucleus and centrosomes. Concerning the cell nucleus the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 471.
1b. the number of nuclei. See S. No. 472.
1c. the staining properties. See S. No. 473.
1d. stages of development. See S. No. 474.
1e. centrosomes. See S. No. 486.

S. No. 471. (cf. S. No. 470). The term cell nucleus designates a well defined protoplasmic body, embedded in the cytoplasm and showing a complex structure; it may be globular, often ellipsoidal, or lenticular; sometimes more elongated, rod-like up to filiform. The cell nucleus may be accompanied by centrosomes, which never appear without it.

S. No. 472. (cf. S. No. 470). With respect to the number of nuclei we may distinguish:
1a. uninucleate cells. Containing only one nucleus. The majority of cells of higher plants.
1b. pluri- or multinucleate cells. Containing more than one, often a very large number of nuclei. *Caulerpa; Cladophora;* the embryosac of *Angiospermae*; latex cells.

S. No. 473. (cf. S. No. 470). With respect to their staining properties we may distinguish:
1a. chromatic substances or chromatin. Retaining stains with some tenacity after extraction.
1b. achromatic substances. By extraction losing their stains, while the chromatin remains still distinctly coloured.

S. No. 474. (cf. S. No. 470). In the development of the nucleus we may distinguish the following stages:
1a. the resting nucleus. No trace of division is discernible. See S. No. 475.
1b. the dividing nucleus. Division is going on. See S. No. 476.

S. No. 475. (cf. S. No. 474). In the resting nucleus we may distinguish:
1a. the nuclear membrane. A thin outer layer of hyaloplasm separating the nucleus from the cytoplasm and surrounding the nuclear cavity. Within it we may observe:
1b. the nuclear network. A coherent reticulum containing a large amount of chromatin. This network is composed of a definite number of chromosomes united together, so that their individual limits are not discernible. In dividing nuclei the chromosomes become visible; see S. No. 480.
1c. nucleoli. More or less globular bodies: mostly 1 or 2 in number in each nucleus, in some cases more numerous.
1d. protein crystals.
1e. the nuclear sap. A fluid filling the rest of the nuclear cavity.

S. No. 476. (cf. S. No. 474). Concerning the dividing nucleus the following subjects will be dealt with:
1a. mother and daughter nuclei. See S. No. 477.
1b. karyokinesis and amitosis. See S. No. 478.

S. No. 477. (cf. S. No. 476). With respect to their mutual relation in the process of nuclear division we may distinguish:
1a. mother nuclei. Considered as belonging to the first generation.
1b. daughter nuclei. Considered as belonging to the second generation.

1c. granddaughter nuclei. Considered as belonging to the third generation.

S. No. 478. (cf. S. No. 476). With respect to the mode of division we may distinguish:
1a. karyokinesis, mitosis or indirect nuclear division. See S. No. 479.
1b. amitosis, fragmentation or direct nuclear division. In higher plants mostly a reduced karyokinetic process.

S. No. 479. (cf. S. No. 478). Concerning karyokinesis the following subjects will be dealt with:
1a. parts, not to be seen in the resting nucleus. See S. No. 480.
1b. stages in karyokinesis. See S. No. 481.
1c. typical and allotypic karyokinesis. See S. No. 482.
1d. haploid and diploid nuclei. See S. No. 483.
1e. development of the tetrad in reduction division. See S. No. 484.
1f. conjugated karyokinesis. See S. No. 485.

S. No. 480. (cf. S. No. 479). In karyokinesis we may distinguish the following parts not to be observed in the resting nucleus:
1a. the polar field or side of the nucleus where the mutual connections of the chromosomes are most permanent.
1b. chromosomes showing their individual limits by the loss of their mutual connections. A definite number of chromosomes occurs in each cell; they have a more or less filamentous form, and are sometimes called nuclear segments or loops. In the course of karyokinesis a longitudinal division or fission of the chromosomes takes place. The longitudinal halves of each chromosome are separated from one another and are transported each to one of the daughter nuclei; this phenomenon is called heteropolia.
1c. the nuclear spindle. A cytoplasmic structure consisting of so-called achromatic spindle fibres, forming at their ends the spindle poles, mostly two in number, pluripolar spindles occurring only in a few cases. It arises from the polar caps, which are formed of so-called cytoplasmic fibres on the outside of the nuclear membrane. These fibres unite into diverging bundles corresponding in place to the poles and after the disappearance of the nuclear membrane they constitute the spindle. Spindle fibres appear in two forms:
    2a. supporting fibres. From pole to pole.
    2b. traction fibres. Extending from one of the poles to a chromosome and attached to it.
1d. the astrosphere or attraction-sphere. Consisting of radiations of protoplasm round the centrosome.

S. No. 481. (cf. S. No. 479). In karyokinesis we distinguish the following stages:

1a. prophases. Changes in the mother nucleus previous to division.

2a. the mother nucleus, still in a resting condition, but ready for division.

2b. the spireme or skein stage. The chromosomes show their individual limits and are arranged so as to form the semblance of a single coil. Some connections remain, especially in the polar field.

2c. the aster or monaster stage. The chromosomes are quite or almost quite free from one another and are assembled in the plane of division, often in the form of a star, sometimes in the form of a plate. Hence the term nuclear or equatorial plate is often used for this stage and the beginning of the metakinesis.

1b. metaphases.

2a. metakinesis. Longitudinal division of the chromosomes is visible, although it mostly appears already in earlier stages. The daughter chromosomes separate; heteropolia.

1c. anaphases. Formation of daughter nuclei. The reverse of the prophases.

2a. the diaster stage. The daugther nuclei are in a stage somewhat resembling the aster stage.

2b. the dispireme. Both daughter nuclei are in a stage resembling the spireme stage.

2c. the daughter nuclei, provided with nucleoli and a nuclear membrane.

S. No. 482. (cf. S. No. 479). With respect to the repartition of chromosomes in the course of karyokinesis we may distinguish:

1a. typical karyokinesis. The number of chromosomes is the same in the daughter nuclei as in the mother nuclei. Vegetative cones.

1b. allotypic karyokinesis, commonly called reduction division. The number of chromosomes in the daughter and granddaughter nuclei is one half of that in the mother nuclei; this division consists of two karyokineses, immediately following one another without a resting stage between, so that four nuclei are formed. Occurring only in certain reproductive cells and mostly starting a new generation. Reduction division being accompanied by cell division a group of four granddaughter cells is formed, which is called a tetrad. See S. No. 484.

The two stages of reduction division are:

2a. the heterotype or first reduction division, in which the reduction of the number of chromosomes takes place.

In this division we distinguish:

3a. the synapsis. A marked contraction of nuclear contents. Chromosomes unite together in pairs called gemini.

3b. the diakinesis. The distribution of chromosomes around the periphery of the nucleus.

2b. the homotype or second reduction division.

The number of chromosomes in daughter and granddaughter nuclei remains the same, being one half of that in the mother nucleus.

As a general rule it may be said that the nuclei of the cells constituting the tetrad contain only a single set of chromosomes which is however sufficient for the formation of a gamete either from the tetrad cells themselves or from their descendants. For such a set of chromosomes the term genom may be used.

S. No. 483. (cf. S. No. 479). With respect to the number of the sets of chromosomes in a single nucleus mentioned in the preceding article we may distinguish:
1a. haploid nuclei and thence haploid organisms, individuals, generations and spores. Each nucleus contains only a single set of chromosomes. Most tetrad cells, most gametophytes (cf. S. No. 25), the sporophyte (carposporophyte or gonimoblast) of haplobiontic *Florideae*, like *Nemalion* and *Batrachospermum.*
1b. diploid nuclei and thence diploid spores. Each nucleus contains two sets of chromosomes. The terms diploid organisms, individuals and generations indicate not only those cases in which each cell contains a diploid nucleus, but also those in which there occurs conjugated karyokinesis (see S. No. 485). Most cells starting for reduction division, most sporophytes; gametophytes only in exceptional cases, like those mentioned under 1c.
1c. triploid, tetraploid etc. nuclei and thence triploid, tetraploid etc. organisms, individuals, generations and spores. Each nucleus contains three, four or more sets of chromosomes. The occurrence of such cases bears always a more or less exceptional character and may be due to various causes. *Oenothera semigigas, O. gigas* and many other similar varieties in their sporophytes. Confer moreover S. No. 26.

S. No. 484. (cf. S. No. 479). Development of the tetrad after reduction division. The formation of tetrads is a complicated phenomenon, which shows many varieties, chiefly appearing in three points: the period in which the two cell divisions take place, the reciprocal arrangement of daughter-, and granddaughter cells respectively and the shapes of the same cells. With respect to the above three kinds of characters we may distinguish the following cases:
1a. the quadripartition type or simultaneous type[1]) of cell division. See S. No. 511. The formation of cell walls is

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[1]) It ought to be kept in mind that in both these cases the existence of normal karyokineses between or before the cell divisions is silently assumed and in this respect the formation of a tetrad is not up to the mark, because the reduction division essentially represents only a single karyokinesis, most generally without a resting stage between its heterotype and homotype phases. Therefore a comparison of quadripartition and bipartition with simultaneous and successive cell division seems to be a halting one. For the sake of continuity, so important a feature

put back till the end of the reduction division, in other words, it takes place after the end of the homotype or second reduction division and then the four granddaughter cells may show:

2a. tetrahedral arrangement, according to the reciprocal position of the vertices of a tetrahedron and then the shape of the granddaughter cells is that of a trihedral pyramid, while the convex external (basal) surface of each tetrad cell forms part of a spherical surface. *Sphagnum, Osmunda regalis* and *Lycopodium,* neutral spores; *Isoetes,* megaspores; *Lythrum Salicaria,* pollen-grains.

2b. arrangement in a single flat plane, and in this case the shape of the granddaughter cells is more or less irregular, however approaching to spherical wedges. *Psilotum,* the majority of the neutral spores; *Alnus glutinosa* and *Impatiens sultani,* pollen-grains.

1b. bipartition type or successive type (See S. No. 511) of cell division. The first formation of a cell wall takes place after the end of the heterotype or first reduction division; the formation of a cell wall in each of the two daughter cells takes place after the homotype or second reduction division. The reciprocal arrangement of the two pairs of granddaughter cells then may be, according to the directions in which the homotype reduction divisions take place: parallel or cross-wise or in any intermediate stage between these two. The shape of the granddaughter cells is then always that of a spherical wedge.

Examples of pollen-grains are afforded in many groups of the higher plants and especially in monocotyledons: e.g. *Curculigo latifolia,* parallel arrangement; *Nidularium princeps* and *Allium Moly,* parallel and cross-wise arrangement intermixed.

In the development of tetrads the formation of the individual partition wall is mostly simultaneous (see S. No. 513); nevertheless successive formation, here called furrowing (see S. No. 513) may occur here and there. Examples are afforded [1] by: *Sisyrinchium; Oenothera, Cannabis sativa* and *Melandryum noctiflorum* (quadripartition type); *Magnolia Yulan* (bipartition type).

Confer for further information S. No. 104, sporangia; S. No. 339, pollen; S. No. 513, furrowing.

S. No. 485. (cf. S. No. 479). Conjugated karyokinesis. This term indicates the simultaneous karyokineses of two nuclei contained in one cell. It is accompanied by a cell division and the result is that in each daughter cell there are contained again two nuclei, respectively a daughter nucleus of each of the two mother

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in terminology, these terms have been used in the text. Nevertheless I do not think it was a happy thought to apply these terms to the phenomena described here. The terms simultaneous and successive cell division (see S. No. 511) were originally divised for designating cell divisions, like those in vegetative cones as contrasting with those leading to the formation of many endosperms.

[1] C. F. Farr, Cytokinesis of the pollen-mother-cells of certain dicotyledons. Mem. New-York Bot. Garden. 6, 1916, p. 253.

nuclei. This phenomenon occurs in cases where a sexual fusion of two cells has taken place, not at once followed by an fusion of the nuclei, the latter taking place at a later stage (delayed karyogamy, cf. S. No. 119). It is clear that notwithstanding the nuclei are haploid, yet such organisms, individuals or generations must be considered as diploid. *Ascomycetes, Basidiomycetes.* Confer moreover S. No. 130.

S. No. 486. (cf. S. No. 470). In cells of some lower plants we may distinguish:
1a. the centrosome (centrosoma). A small definite portion of protoplasm, surrounding a still smaller body called centriole, and lying close near the nucleus. During nuclear division the centrosome is divided into two and one centrosome is placed at each pole of the nuclear spindle.

S. No. 487. Plastids. (cf. S. No. 461). Concerning plastids the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 488.
1b. inclusions of non-living substances. See S. No. 489.
1c. shape of plastids. See S. No. 496.
1d. kinds of plastids with respect to the character of their inclusions. See S. No. 497.

S. No. 488. (cf. S. No. 487). The term plastids designates well defined protoplasmic bodies, embedded in the cytoplasm; mostly of smaller dimensions than the nucleus, and in most protoplasts occurring in large numbers. They exhibit various simple shapes, being globular, ellipsoidal, lenticular or rod-shaped; they are often coloured in various ways.

S. No. 489. (cf. S. No. 487). In plastids we may distinguish the following inclusions of non-living substances:
1a. pigments. The most interesting kinds of these are known under the following collective names:
  2a. carotinoids. Red or yellow pigments. Occurring in all green coloured plastids.
  2b. chlorophyll. Collective name for green pigments. Occurring in all green coloured plastids.
  2c. phycocyanin. A blue pigment. Occurring in *Schizophyceae.*
  2d. phaeophyll. A brown pigment. Occurring in *Phaeophyceae.*
  2e. phycoerythrin. A red pigment. Occurring in *Rhodophyceae.*
1b. albumen crystals. In leucoplasts; see S. No. 497.
1c. amylum grains. See S. No. 497.
1d. amylum-bodies. More or less spherical protoplasmic bodies. *Spirogyra* and many other *Algae.* They often contain:

2a. pyrenoids. Albuminous bodies, mostly 1 in the centre of the amylum-body, and surrounded by:
2b. starch grains, sometimes arranged in a ring. See S. No. 490.

S. No. 490. (cf. S. No. 489). Concerning starch grains the following subjects will be dealt with:
1a. meaning of the term. See S. No. 491.
1b. hilum and stratification. See S. No. 492.
1c. position of hilum. See S. No. 493.
1d. number of hila. See S. No. 494.
1e. shape of starch grains. See S. No. 495.

S. No. 491. (cf. S. No. 490). In the ordinary course of micrography botanists call starch grains all grains colouring blue by a solution of iodine containing a certain amount of water. To this iodine test was originally added a control test establishing that in a dilute watery solution of iodine the blue colour disappears on heating and reappears on cooling; this control is now generally omitted.

S. No. 492. (cf. S. No. 490). In starch grains we may distinguish, either at once or after the addition of reagents promoting differences of refrangibility:
1a. the hilum or nucleus. The organic centre or nucleus of formation of the grain. In this place there is often a fissure, in a dry state commonly filled with air and in many cases radiating from the centre of the grain.
1b. stratification. Concentric layers surrounding the hilum.

S. No. 493. (cf. S. No. 490). With respect to the position of the hilum we may distinguish:
1a. concentric starch grains or grains with a central hilum. The hilum occupies the centre of the grain; the stratification is symmetrical about the centre. Endosperm of *Triticum.*
1b. excentric starch grains or grains with an excentric hilum. The hilum does not occupy the centre of the grain; the stratification is not on all sides symmetrical about the centre of the grain. The position of the hilum is indicated by means of a fraction of which the numerator and the denominator correspond with the ratio between the distances of the excentric hilum from the margin of the grain on both sides in the direction of the excentricity. Thus the fraction $^1/_3$ indicates that the hilum is situated at one fourth part of the diameter. Tubers of *Solanum tuberosum.*

S. No. 494. (cf. S. No. 490). With respect to the number of hila we may distinguish:
1a. starch grains containing only one hilum.
2a. simple grains. Endosperm of *Secale cereale.*
1b. starch grains containing more than 1 hilum.

2a. compound grains. Formed by an aggregate of simple grains themselves, called component grains. According to the number of component grains we can distinguish bi-, tri- up to polyadelphous compound grains. Endosperm of *Oryza*.

2b. half-compound grains. Consisting of two or more simple grains, held together by common enveloping layers of starch substance. A certain number of grains in potato starch.

S. No. 495. (cf. S. No. 490). With respect to their shape we may distinguish the following starch grains:
1a. spherical, oval, ovate and ellipsoidal. Potato starch, seeds of *Pisum sativum*.
1b. polyhedral. Seed of *Zea Mays*.
1c. disc-shaped, often at the margin with a small conical protuberance, containing the hilum. Rhizomes of *Zingiberaceae*.
  2a. lenticular starch grains. Endosperm of *Triticum*.
1d. bar-shaped or rod-shaped.
  2a. needle-shaped. Many chloroplasts proper.
  2b. dumb-bell-shaped. Latex of *Euphorbia splendens*.

S. No. 496. (cf. S. No. 487). With respect to their shape we may distinguish the following kinds of plastids:
1a. spherical and ellipsoidal. Many chloroplasts and leucoplasts; see S. No. 497.
1b. bar- or rod-shaped. Leucoplasts in the rhizome of *Iris*, leuco- and chloroplasts in aerial tubers of *Phajus grandifolius;* see S. No. 497.
1c. triangular, spindle-shaped and needle-shaped. Many chromoplasts; see S. No. 497.
1d. disc-shaped:
  2a. lenticular. Many chloroplasts in leaves.
  2b. tabular. Chloroplasts of *Mougeotia* and *Diatomeae*.
  2c. stellate. Chloroplasts of *Zygnema;* see S. No. 497.
  2d. plastids in the shape of spiral bands. Chloroplasts of *Spirogyra;* see S. No. 497.

S. No. 497. (cf. S. No. 487). With respect to the character of the inclusions we may distinguish:
1a. chloroplasts. Containing besides carotinoid pigment, in most, perhaps in all cases, chlorophyll and generally coloured green; in some groups of *Algae* moreover containing one of the other pigments enumerated in S. No. 489, and accordingly coloured otherwise. Especially in higher plants we may distinguish:
  2a. ordinary chloroplasts, chloroplasts proper. Containing mostly small, though sometimes numerous starch grains, which soon disappear in darkness; in *Algae* sometimes containing amylum-bodies, see S. No. 489; chlorenchyma in leaves.
  2b. spurious chloroplasts, chloroplasts improper. Containing often larger, sometimes very large, generally not

very large, generally not very numerous starch grains, which do not disappear after a short time in darkness. Cells of starch sheaths, guard cells of stomata.
1b. leucoplasts, amyloplasts, starch builders. Containing no pigment, but generally a large amount of starch, either large grains in small numbers or numerous small grains; sometimes also albumen crystals. Organs carrying reserve materials, tubers, seeds, etc.
1c. chromoplasts. Containing pigments only of the carotinoid group, coloured yellow to brick red; sometimes containing crystals of pigment and often triangular, needle-shaped, spindle-shaped or tabular in consequence of this cristallization; arising from colourless plastids or chloroplasts; often falling asunder into minute granules soon after their formation; in a few cases showing amoeboid creeping movements (*Iris Kamorensis*, Weiss); mostly without starch grains, sometimes containing a few. Flowers, fruits.

S. No. 498. (cf. S. No. 461). Vacuoles. Concerning vacuoles the following subjects will be dealt with:
1a. the meaning of the term. See S. No. 499.
1b. number. See S. No. 500.
1c. shape. See S. No. 501.
1d. size. See S. No. 502.
1e. contents. See S. No. 503.
1f. contractile vacuoles. See S. No. 508.

S. No. 499. (cf. S. No. 498). The term vacuoles designates cavities in the cytoplasm, filled with non-living substance, mostly in a fluid state. They exhibit the most various dimensions, often a single one forming the bulk of the cell body, in other cases however being very small.

S. No. 500. (cf. S. No. 498). The number of vacuoles in the protoplast is various; it may be very large.

S. No. 501. (cf. S. No. 498). Shape of vacuoles. Being cavities mostly filled with fluid and surrounded by living protoplasm, the vacuoles tend to become spherical as far as circumstances allow.

S. No. 502. (cf. S. No. 498). With respect to size we may distinguish:
1a. sap cavities. Large vacuoles of which a single one or a few form the bulk of the cell body. Their contents form the cell sap proper.
1b. adventitious vacuoles. Small vacuoles in cells containing also one or more sap cavities. They are of very common occurrence and mostly numerous. Epidermal cells of the petals of *Malva sylvestris*.

S. No. 503. (cf. S. No. 498). The contents of the vacuoles are of the most varied kinds and different vacuoles of the same protoplast show often distinctly different contents. These are mostly clear fluids and for the greater part watery solutions of an innumerable variety of substances; in a certain number of cases there are to be found solid bodies with or without fluid. The identity of substances occurring in the contents of vacuoles must in all cases be determined by means of chemical analysis. The results are described with the help of chemical terminology, which cannot be explained here. Yet some inclusions in vacuoles may be recognised without chemical tests; the following of these may be mentioned:

1a. crystals. See S. No. 504.
1b. aleurone grains. See S. No. 505.
1c. anthocyanin. See S. No. 506.
1d. siliceous bodies. See S. No. 507.

S. No. 504. (cf. S. No. 503). Crystals in vacuoles. They belong to various substances, nevertheless those consisting of calcium oxalate are by far of the most general occurrence. In the ordinary course of micrography crystals are supposed to consist of calcium oxalate if they persist in acetic acid, but disappear in hydrochloric or sulphuric acid, in the latter case a great number of very small crystals of calcium sulphate is formed on the surface of the original crystal, rendering this greyish and less transparent.

In most cases it is impracticable for anatomists to determine by means of crystallographical methods the precise character of the observed crystals. Thus the following collective terms are generally used in micrography:

1a. simple crystals, twin crystals etc. *Hyoscyamus niger,* mesophyll of leaf.
1b. cluster crystals, aggregates of crystals more or less in the form of a morning-star. *Punica Granatum,* bast parenchyma.
1c. raphides. Needle-shaped crystals pointed at both ends; in most cases they are very numerous and form regular bundles lying in a mucilaginous substance. *Urginea Scilla,* scales of bulb.
1d. crystal sand. A mass of very small more or less irregular crystals. *Atropa Belladonna,* mesophyll of leaf.
1e. sphaerites. Spheroidal bodies composed of radiating crystal needles often arranged in concentric layers ¹). *Mamillaria Wildiana,* parenchyma in protuberances of stem ²).

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¹) Sphaerites of soluble carbohydrates and of many unknown substances often may be formed in tissues, when preserved in alcohol; these sphaerites, being formed post mortem are not to be described as parts of the plant. They are not strictly localized to the vacuoles, but may be formed anywhere in the tissues irrespective of their organization. Especially when the crystallization process is very slow, there may be formed large sphaerites, extending through the cell-walls over a number of cells. *Scorzonera hispanica,* sphaerites of inulin.

²) H. Solereder, Systematische Anatomie der Dikotyledonen, Stuttgart 1899, p. 467.

S. No. 505. (cf. S. No. 503). Aleurone grains. The albuminous contents of small and mostly numerous vacuoles in a dry state. Endosperm of many seeds; *Acacia spadicigera:* Belt's food-bodies. In many aleurone grains certain inclusions may be found often of more than one kind in the same grain. The following may be distinguished:
1a. albumen crystals. Endosperm of *Ricinus communis* and *Myristica fragans.*
1b. globoids. Small globular bodies consisting chiefly of phosphate of calcium and magnesium; often numerous. Endosperm of *Ricinus.*
1c. crystals of calcium oxalate either simple, twins, or cluster crystals. Endosperm of *Pimpinella Anisum.*

S. No. 506. (cf. S. No. 503). Anthocyanin. Pigments, mostly blue in an alkaline, red in an acid cell sap; generally in a dissolved condition, not infrequently solid, crystalline or amorphous. Flowers of carmine red or blue colours; young and old foliage leaves.

S. No. 507. (cf. S. No. 503). Siliceous bodies of a more or less irregular, clustered shape may occur in cells belonging to the parenchymatic system of secondary xylem. *Chrysobalanaceae, Myrtaceae* and *Leguminosae.*

S. No. 508. (cf. S. No. 408). Contractile vacuoles. Gradually increasing in size, then suddenly vanishing, then swelling again into view and so on. Swarm-spores.

S. No. 509. Cell reproduction (cf. S. No. 458). In cell reproduction we may distinguish with respect to the relation between mother- and daughter-cells:
1a. cell division. The mother-cell is simply divided into two or more daughter-cells, which formerly constitued integral parts of the mother-cell. See S. No. 510.
1b. cell budding. The mother-cell pushes out one or more protuberances, often separated from it by a constriction; from these protuberances the daughter-cells arise. *Saccharomyces;* basidiospores, (cf. S. No. 130); *Characeae,* sporostegium (cf. S. No. 162).

S. No. 510. (cf. S. No. 509). Concerning cell division the following subjects will be dealt with:
1a. the relation between cell division and nuclear division. See S. No. 511.
1b. the relation of the daughter-cells towards one another and towards the cytoplasm of the mother-cells. See S. No. 512.
1c. parts, not to be seen in the non-dividing cell. See S. No. 513.

S. No. 511. (cf. S. No. 510). With respect to the relation between cell division and nuclear division we may distinguish:

1a. cell division independent of nuclear division, the latter being called in this case: Free nuclear division. Plurinuclear cells of *Thallophytes.*
1b. cell division in close local connection with nuclear division. The most common case.
2a. successive cell division. In uninuclear cells each nuclear division is followed by a cell division. Vegetative cones; formation of pollen-tetrads in the majority of *Monocotyledons.*
2b. simultaneous cell division. A certain number of nuclear divisions having taken place, the mother-cell is divided into more than two daughtercells. *Isoetes,* megaspore; *Cycadaceae,* e.g. *Dioon, Fritillaria imperialis,* formation of endosperm; formation of pollen-tetrads in the majority of *Dicotyledons.*

S. No. 512. (cf. S. No. 510). With respect to the relation of the daughter-cells towards one another and the cytoplasm of the mother-cell we may distinguish:
1a. ordinary cell division. The daughter-cells are in contact with one another; the whole cytoplasm of the mother-cell is used up in their formation.
1b. free cell formation. The daughter-cells are not in contact with one another; the cytoplasm of the mother-cell is not used up in their formation. Formation of ascospores in *Ascomycetae.*

S. No. 513. (cf. S. No. 510). In the process of cell-division we may distinguish:
1a. protoplasmic fibres, preceding the formation of a partition wall.
2a. connecting fibres. They unite the nuclei between which a cell wall is about to arise and a barrel-shaped figure is often formed by them. Most cases of ordinary cell division, either successive or simultaneous.
2b. fibres radiating into the cytoplasm. Many cases of free cell formation. *Aneima fraxinifolia.*
1b. the cell plate. Consisting of short rod-shaped thickenings of the protoplasmic fibres at the place where the new cell wall is to be formed. In ordinary cell division it mostly appears in the equatorial plane of the connecting fibres between two cell nuclei.
1c. the partition wall. The newly formed cell wall. It may be:
2a. simultaneously formed. Appearing at once from a well developed cell plate. The most common case.
2b. successively formed. Appearing as an annular projection from the inside of the wall of the mother cell, and gradually closing up towards the middle. *Spirogyra;* in pollen-grains successive formation of partition walls may sometimes appear and is there called furrowing (cf. S. No. 484).

S. No. 514. (cf. S. No. 458). Internal streaming movements of the protoplasm. Internal streaming movements occur in two kinds:

1a. often quick enough for direct observation under the microscope.

2a. rotation. There is a single stream, moving in all parts of the cytoplasm, and in one direction only, a neutral line without movement separating parts of the stream passing in opposite directions. *Nitella.*

2b. circulation. Movement in isolated streams.

3a. parietal circulation. Streams running in the parietal cytoplasm.

3b. central circulation. Streams running in the cytoplasmic strings. Staminal hairs of *Tradescantia virginiana.*

2c. streaming to and fro. A single stream moving in one direction towards the end of the protoplasmic body, and after an interval moving back in an opposite direction. Plasmodia of *Myxomycetae.* Hyphae of *Fungi.*

1b. movements mostly too slow for direct observation under the microscope.

2a. movements of orientation. Recognizable only through their effect on the position of the protoplasmic bodies, especially the chloroplasts. In connection with these movements we may distinguish the following positions:

3a. epistrophe, transverse position. The plastids are crowded along the cell walls that are parallel to the surface of the organ.

3b. apostrophe, profile position. The plastids are crowded along the cell walls that are at right angles to the surface of the organ. The natural position of chloroplasts in palisade chlorenchyma; see S. No. 631.

3c. systrophe. The plastids are massed together in the vicinity of the cell nucleus.

S. No. 515. The cell wall. (cf. S. No. 456). Concerning the cell wall the following subjects will be dealt with:

1a. growth. See S. No. 516.
1b. thickness. See S. No. 517.
1c. a coarser structure. See S. No. 518.
1d. a finer structure. See S. No. 519.
1e. colour. See S. No. 520.
1f. cell wall substances. See S. No. 521.
1g. relief figures, caused by unequal thickening. See S. No. 524.
1h. perforations. See S. No. 548.
1i. schizogenous intercellular spaces. See S. No. 549.

S. No. 516. (cf. S. No. 515). Growth of cell walls may take place in surface or in thickness. It may be the consequence of two processes:

1a. apposition. Layers of new substance are deposited on the surface of existing cell walls.

1b. intussusception. Intercalation of particles of new substance between the already existing particles of the cell wall.

S. No. 517. (cf. S. No. 515). Thickness. All cell walls originally arise as very thin membranes and afterwards are thickened often in a very high degree. Cell walls or considerable areas of them, strongly thickened, moreover hard and mostly lignified are called sclerenchymatous (sclerotic).

The thickness of cell walls adjoining those of other cells in tissues is determined for each cell separately. The adjoining cell walls in some cases may be of very different thickness.

S. No. 518. (cf. S. No. 515). The coarser structure. In the cell wall we may often distinguish more than one kind of thickening layers, differing from one another in optical appearance and chemical constitution.

The double cell walls in tissues separating the cavities of adjoining cells from one another generally show the following layers:

1a. the middle lamella. Consisting of the primitive membranes, forming the original cell walls, fused together with the primary thickening layers of the adjoining cells. Thus a homogeneous, mostly thin lamella appears seemingly belonging in common to both adjoining cells. In places where more than 2 cells meet together dilated parts of the middle lamella occur, called gussets; within the gussets intercellular spaces may appear.

1b. secondary thickening layers. Adjoining the middle lamella on both sides; the most strongly developed parts of the cell wall in fact generally forming the bulk of it. In fibres belonging to secondary xylem and phloem either all the secondary layers or only the inner ones are sometimes developed as a gelatinous layer, mostly not lignified; this layer often exhibits folds and is often more or less detached from the others; in most woods it occurs, but only here and there.

1c. tertiary thickening layers. The layers bordering upon the cell cavities not always to be distinguished, mostly very thin and more highly refractive. Cellulose layer in periderm cells; wood of the second and later growth rings of *Populus pyramidalis*.

S. No. 519. (cf. S. No. 515). The finer structure. This is often to be observed without the action of any reagent, but in many cases thickening layers appearing homogeneous exhibit a distinct finer structure when becoming swollen after treatment with acids, alkalies, oil of turpentine etc. We may distinguish:

1a. stratification. Concentric thicker dense layers, recognizable by high refractive power, alternate with thinner less dense ones.

1b. striation. In surface view we may often observe delicate striae in the cell wall, mostly in great number and running parallel to each other; in most cells their direction is oblique in the sense of a sinistrorse spiral. Cell walls exhibiting oblique striation generally have a lattice-work appearance, while the striae at both sides of the middle lamella, formed by the two adjoining cells, are more or less perpendicular to each other.

A cellulose reaction with iodine and subsequent treatment with zinc chloride or sulphuric acid is especially adapted to make striation visible. Examples of striation visible without reagents: pericyclic fibres of *Vinca minor*, some tracheid fibres of *Pinus*.

S. No. 520. (cf. S. No. 515). Colour. The majority of cell walls is colourless; they are often coloured yellowish or brown and especially in heart wood show several conspicuous colours. For the determination of colours confer S. No. 34.

S. No. 521. (cf. S. No. 515). Cell wall substances. We may distinguish:
1a. organic substances. See S. No. 522.
1b. inorganic substances. See S. No. 523.

S. No. 522. (cf. S. No. 521). Organic cell wall substances. A great number of various substances may be found in cell walls. Only a few of the most important are enumerated here. Some of the terms by which they are designated are of chemical origin, others have a more botanical or anatomical meaning.
1a. pectin substance. Occurring in all layers of the cell wall but especially conspicuous in the middle lamella. In the living plant they often pass into a state of solution and thus promote the formation of intercellular spaces (see S. No. 549) and the phenomenon of sliding growth (secondary xylem, hyphae).
As special terms for designating certain layers of the cell wall chiefly consisting of pectin substances, which may however be mixed with cellulose, we may distinguish:
2a. the endosporium or endospore of spores, called intine in the case of pollen-grains.
1b. cellulose. Occurring in all layers; most conspicuous in the secondary and tertiary thickening layers; wanting in the primitive membrane. It may be obtained by special treatment within the cells in a crystallized condition, in the form of sphaerites or dendrites. In the ordinary course of micrography botanists call cellulose all cell wall substances colouring blue after treatment with iodine followed by sulphuric acid 66 per cent, or another auxiliary reagent.
1c. amyloid substances. Cell wall substances colouring blue in a dilute solution of iodine without addition of an auxiliary reagent. *Tropaeolum majus*, secondary layers in parenchyma cells of cotyledon.
1d. corky substances. Mixture of fats and some other substances; phellonic and suberic acid playing a prominent part among their constituents. The deposition of these fatty substances is often accompanied by disproportionate increase of surface, causing folds of the whole cell walls or of certain layers. In the ordinary course of micrography botanists often call corky substances those cell wall substances which without being lignified withstand the action of concentrated sulphuric acid.
2a. suberin proper. Chiefly occurring in the secondary thickening layers. Periderm cells, oil cells.

2b. cutin. Phellonic acid is wanting in this substance. Cutin occurs in:

3a. the cuticle. A layer consisting of the outer part of the surface wall of the epidermis cells in many organs, and forming a continuous layer, independent of the outlines of the cells. This layer contains no cellulose. Its free surface often shows small projections of different kinds, centrifugal relief figures. See S. No. 547.

3b. the cuticular layers. Cellulose layers lying beneath the cuticle, bordering upon it and containing cutin.

3c. the exosporium or epispore of spores and the exine of pollen grains or pollinia *(Orchideae)*. These layers may have a smooth outer surface, but often show protuberances, see S. No. 547. They contain cellulose.

2c. vittin. Corky substance, containing no phellonic acid and to be found in the inner epithelium walls which border upon the cavity of the vittae (see S. No. 646) in *Umbelliferae*. This substance moreover forms a layer covering these cell walls, thus lining the cavity of the gland; it even forms transverse partition walls dividing the cavity.

1e. lignification. This is the state of cell walls containing several substances which make them hard and brittle, in a word woody and resisting the action of concentrated sulphuric acid. In the ordinary course of micrography botanists call cell walls lignified if they are woody and colour red after treatment with phloroglucine and hydrochloric acid. This reaction may appear in all layers of the cell wall, but is often especially strong in the middle lamella; lignification by no means excludes the presence of cellulose. Secondary xylem and other sclerotic tissues, like stones of fruits etc.

1f. chitin. In micrography cell wall substances are called chitin if they are coloured violet by the action of an iodine solution acidulated with sulphuric acid after previously having been heated up to 160° C in a solution of potash. The presence of chitin excludes that of cellulose. Many cell walls of the higher *Fungi*.

1g. gums and mucilaginous substances. Practically characterized in micrography by their tendency to swell up in water. Gummosis of *Amygdalaceae;* epidermis of seed coat in *Linum*.

1h. waxy substances. Chiefly characterized by a melting point beneath 100° C and by being soluble in several of the same reagents as bees wax, but by no means identical to the latter from a chemical point of view. These substances occur in the cuticle or cuticular layers (*Acer striatum*) or in the form of a waxy covering on the outside of the cells. This covering may appear as a continuous layer *(Klopstockia cerifera)*, consist of fine rods *(Saccharum officinarum, Secale cereale)* or of granular matter *(Tropaeolum, Ricinus communis)*.

S. No. 523. (cf. S. No. 521). Inorganic cell wall substances. The following are the principal ones:

1a. calcium oxalate in crystal form. Sclerenchyma fibres of *Welwitschia mirabilis*; surface walls of many epidermal cells; internal hairs of *Nymphaea*.

Many large crystals having their place in the centre of cells are enveloped in crystal skins, composed of organic cell wall substance and connected with the cell wall. Confer moreover S. No. 504.

1b. calcium carbonate. Impregnating organic cell wall substances (cystoliths; see S. No. 545), often moreover covering the free surfaces of impregnated cell walls and then sometimes in a more or less crystallized condition (*Chara;* many *Algae*, especially *Corallinaceae)*.

1c. silica. Impregnating cell wall layers consisting of organic substances.

2a. in superficial cell walls (*Diatomeae*; epidermis of *Equisetaceae* and *Gramineae)*.

2b. in outgrowths, protruding inward from tangential cell walls of stegmata or covering plates, (see S. No. 632). *Palmae, Ferns.*

For siliceous bodies confer S. No. 507.

S. No. 524. Relief figures. (cf. S. No. 515). The thickenings of cell walls seldom extend uniformly over the whole area of the walls. Thus relief figures are formed and among them we may distinguish:

1a. centripetal relief figures. Thickening layers deposited on the inside of the cell wall, protuberances projecting into the cell cavity. See S. No. 525.

1b. centrifugal relief figures. Thickening layers deposited on the outside of the cell wall; protuberances projecting from the free outer surface of the cell wall. See S. No. 547.

S. No. 525. (cf. S. No. 524). Centripetal relief figures. We may distinguish:

1a. pits. See S. No. 526.
1b. annular thickenings. See S. No. 541.
1c. spiral thickenings. See S. No. 542.
1d. reticulate thickenings. See S. No. 543.
1e. bar-like thickenings. See S. No. 544.
1f. cystoliths. See S. No. 545.
1g. collenchymatous thickenings. See S. No. 546.

S. No. 526. (cf. S. No. 525). Concerning pits the following subjects will be dealt with:

1a. the meaning of the term. See S. No. 527.
1b. the abutting of pits. See S. No. 528.
1c. arrangement. See S. No. 529.
1d. simple and bordered pits. See S. No. 530.
1e. pits of adjoining cells and abutting on one another considered as a whole; closing membrane. See S. No. 540.

S. No. 527. (cf. S. No. 526). Pits. Gaps in the internal thickening of the wall. Thus a pit canal is formed, passing transversely through the wall and varying in length according to the degree of thickening. Walls exhibiting pits and cells having such walls, are called pitted.

S. No. 528. (cf. S. No. 526). The pits may abut in various ways and in this respect we may distinguish:
1a. pits in cell walls, contiguous with the cell walls of adjoining cells, correspond in place to those of the adjoining cells. See S. No. 540.
1b. the pits lead towards intercellular spaces. Procumbent cells of medullary rays in secondary xylem.
1c. the pits lead towards the free surfaces of cells. *Saccharum officinarum,* epidermal cells of stem; so called tactile pits of tendrils.

S. No. 529. (cf. S. No. 525). Pits are often arranged in a more or less regular manner. We may distinguish:
1a. a uniform distribution. The ordinary case.
1b. groups of different shapes. Wood parenchyma cells in their radial walls.
1c. in regular rows:
  2a. longitudinally directed. Many libriform and tracheid fibres.
    3a. vertically alternate. Pits of neighbouring longitudinal rows alternating. *Araucaria,* the common case in fibre tracheids [1]).
    3b. vertically opposite. Pits of neighbouring longitudinal rows at the same level. *Araucaria,* sometimes in fibre tracheids.
  2b. transversely directed. Procumbent cells of medullary rays in their transverse and radial walls.
    3a. horizontally alternate. Pits of neighbouring transverse rows alternating. *Araucaria,* a common case for pits between fibre tracheids and medullary ray cells.
    3b. horizontally opposite. Pits of neighbouring transverse rows placed over each other.
  2c. spiral rows, mostly sinistrorse. Many vessels in secondary xylem in their longitudinal walls.

S. No. 530. (cf. S. No. 526). With respect to the pit canal we may distinguish:
1a. simple pits. Pit canal equally wide throughout or widening towards the cell cavity; in a very few cases expanding towards the periphery of the cell wall (tactile pits, cf. S. No. 528 in tendrils; *Dammara alba,* sclerenchyma cells of wood parenchyma fibres [1])). A few xylem vessels, many fibres and most parenchyma cells. See S. No. 531.
1b. bordered pits. Pit canal narrowing suddenly towards the

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[1]) D. J. W. Pool. On the anatomy of Araucarian wood. Recueil trav. bot. néerl. 25, 1928, p. 484.

cell cavity. The occurrence of these pits is limited to xylem elements and transfusion tissue elements. The majority of vessels and many fibres in secondary xylem, many transfusion cells. See S. No. 535.

S. No. 531. (cf. S. No. 530). Concerning simple pits the following subjects will be dealt with:
1a. shape. See S. No. 532.
1b. branching. See S. No. 533.
1c. combined simple pits. See S. No. 534.

S. No. 532. (cf. S. No. 531). Simple pits according to their shape in surface view of cell walls may be distinguished as:
1a. circular.
1b. slit-like. Elliptical or more or less elongated. Often placed obliquely and arranged in sinistrorse spirals. In thick cell walls it is often only the aperture, leading from the pit canal into the cell cavity which shows one of the shapes mentioned above. Libriform fibres with simple pits.

S. No. 533. (cf. S. No. 531). Branched simple pits. Arise when the canals of several pits unite during continued thickening of the walls. Sclereids of stones in fruits.

S. No. 534. (cf. S. No. 531). Combined simple pits. In much elongated pits the aperture leading towards the cell cavity may be still more elongated than the rest of the pits; these strongly elongated parts may fuse together with those of adjacent pits, placed in the same row and thus on the inner surface of the cell wall furrows are formed receiving each two or more pits. *Pometia tomentosa*, libriform fibres.

S. No. 535. (cf. S. No. 530). Concerning bordered pits the following subjects will be dealt with:
1a. structure. See S. No. 536.
1b. shape in surface view of cell walls. See S. No. 537.
1c. combined bordered pits. See S. No. 538.
1d. sieve structure of the closing membrane or vestured pit structure. See S. No. 539.

S. No. 536. (cf. S. No. 535). In bordered pits we may distinguish:
1a. the border of the pit or halo (halos). The part of the cell wall surrounding the canal and overlapping the closing membrane (see S. No. 540). The border has an outline where it is inserted in the normal cell wall around the pit and one or two central edges, caused by the presence of the aperture or apertures (see 1b.). The outline of the border may be circular, but also elliptical, much elongated, polygonal or of irregular shape. The elliptical or elongated halo is directed transversely, obliquely or even longitudinally. The halo consists of:

2a. the primary border membrane. An infundibular outgrowth of the middle lamella, containing much pectic substance and covering the border at the outside, i.e. the side turned towards the cavity of the pit. The primary border membrane is formed early during the development of the pit. At the edge where the primary border membrane meets the closing membrane and the middle lamella of the normal wall round about the pit, a thickened band of pectic substances is to be found, the pectic annulus[1]).

2b. the secondary border membrane. Generally lignified and covering the primary border membrane at the inside, i.e. towards the cell cavity. The secondary border membrane is laid down after the completion of the primary border membrane.

1b. the canal of the pit. This may consist of:

2a. the cavity of the pit (pit chamber). The much widened outer part of the pit canal; mostly planoconvex.

2b. the not widened part of the pit canal. According to the extent of thickening of the cell wall we may distinguish:

3a. a sharp edged aperture. Leading from the pit chamber into the cell cavity: it may be circular, elliptical or elongated. *Pinus sylvestris,* tracheid fibres of spring wood.

3b. the tubular part of the pit canal. Often a relatively long part, exhibiting:

4a. the inner aperture. Circular or slit-like and leading into the cell cavity.

4b. the outer aperture. Circular or slit-like and leading into the pit chamber. Of the same size or smaller than the inner aperture; the tubular part of the canal consequently often narrowing towards the pit chamber.

1c. the torus. A local, plano-convex thickening of the closing membrane (see S. No. 540). It corresponds in place to the not widened part of the pit canal.

1d. the margo. The thin part of the closing membrane, surrounding the torus.

S. No. 537. (cf. S. No. 535). Bordered pits according to their shape in surface views of cell walls may be distinguished as:

1a. circular. Halo and sharp edged aperture or tubular part of canal of the bordered pit more or less circular. *Pinus sylvestris,* tracheid fibres.

1b. slit-like. Halo and sharp edged aperture or inner and outer aperture more or less elongated. The shape of those several parts is often different in one and the same bordered pit; in this respect we may find all possible combinations in which at least one of those parts is elongated. Often placed obliquely and arranged in sinistrorse spirals. *Quercus,* vessels and tracheid fibres of secondary xylem.

2a. scalariform. Strongly slit-like, moreover transversely directed and arranged in longitudinal rows. *Pteris aquilina,* vessel tracheid.

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[1]) D. J. W. Pool, l.c.

S. No. 538. (cf. S. No. 535). Combined bordered pits. In much elongated bordered pits the sharp edged apertures or the inner apertures of the canals may be still more elongated than the rest of the pits; these strongly elongated parts may fuse together with those of adjacent bordered pits placed in their prolongation and thus on the inner surface of the cell wall furrows are formed, each connected with two or more pit chambers.

S. No. 539. (cf. S. No. 535). Sieve structure or vestured pit structure. A punctuate appearance shown by the closing membrane of the bordered pits of *Leguminosae* and some other plants has been described as due to the presence of numerous small perforations; according to Bailey (Tropical Woods 31, 1932, p. 46) it is however due to the presence of minute projecting outgrowths.

S. No. 540. (cf. S. No. 526). Pits were considered in the cases mentioned above as belonging to the wall of the single cell. In the ordinary course of micrography however pits belonging to adjoining cells and abutting on one another are generally described as a whole. In these cases the two adjoining unthickened parts of the cell walls fused together and separating the pits from one another, form the closing membrane (limiting lamella). When on both sides of the closing membrane narrow elliptical or elongated pits occur, arranged in mostly sinistrorse spiral lines (cf. S. No. 532), the oblique pits in the adjoining cells may appear to cross one another.

The two pits combined together may be of the same but also of different kinds and, as the three possible different combinations do occur, we may distinguish:

1a. bilateral or two-sided simple pits, practically always called simple pits without any addition. Occurring in the walls of parenchyma cells abutting either on cells of the same order or on certain fibres or in a few cases on xylem vessels; also in the walls of certain fibres abutting on elements of the same order.

1b. bilateral or two-sided bordered pits, practically always called bordered pits without any addition.

The two pit chambers together are designated as lens shaped pit cavity. As on both sides of the closing membrane a torus (cf. S. No. 536) is formed there appears a biconvex torus in this combination.

The terms inner and outer aperture of the canal of the bordered pit though appropriate for the description of the single cell are less so for the combination of pits mentioned here. But there is no help for it.

Either occurring in the walls of xylem vessels and fibres abutting on elements of the same order or in the walls of vessels abutting on fibres.

1c. unilateral or one-sided bordered pits (semi-bordered pits). On one side of the closing membrane a simple pit, on the other side a bordered pit appears. The terms inner and outer aperture here also are less appropriate. In walls of parenchyma cells abutting either on xylem vessels or on certain fibres.

In the combinations, mentioned above, the pits retain the size and peculiar shape, belonging to them in the elements which form the combination. Therefore the resemblance in the two cases first mentioned is in some respects a limited one. It is only complete when elements of the same kind are contiguous with one another. Thus for instance if in secondary xylem a parenchymatic cell and a libriform fibre adjoin one another, there may certainly occur bilateral simple pits but mostly the parenchymatic element will show circular, and the libriform fibre slit-like pits.

S. No. 541. (cf. S. No. 525). Annular thickenings. Mostly lignified. Vessels in primary xylem; *Sphagnum*, water tissue.

S. No. 542. (cf. S. No. 525). Spiral thickenings. They may occur:

1a. on the inside of otherwise not thickened walls. Mostly lignified (excepted e.g. *Zingiber officinale*, spiral vessels in the rhizome) and in most cases dextrorse, in contrast with the prevailing direction of the cell wall striation and of elongated pits (cf. S. No. 519 and 529). Spiral vessels in primary xylem; *Trichia varia*, fibres of capillitium; *Marchantia polymorpha*, elaters. There may be only one spiral *(Jungermanniaceae Jubuloideae*, elaters), two spirals (most *Jungermanniaceae acrogynae*) or more of them (*Nepenthes* spp., peculiar spiral cells).

1b. on the inside of strongly thickened walls. Often in tracheal elements of secondary xylem, e.g. *Tilia platyphyllos*, vessels; *Taxus baccata*, tracheid fibres.

S. No. 543. (cf. S. No. 525). Reticulate thickenings. Reticulate vessels; *Dendrobium*, velamen of aerial roots; *Marchantia polymorpha*, parenchyma cells of ground tissue.

S. No. 544. (cf. S. No. 525). Bar-like thickenings. Ingrowths protruding in a conical or bar-like, often branched form into the cell cavity. They are often arranged on the cell wall in a spiral line. They may also stretch transversely across the cell cavity (transverse bars and trabeculae). *Marchantia polymorpha*, rhizoids; *Juniperus Sabina*, mesophyll of leaf; *Pinus sylvestris*, tracheid fibres with transverse bars; *Caulerpa* with trabeculae.

S. No. 545. (cf. S. No. 525). Cystoliths. Peculiar ingrowths of the cell wall, protruding into the cell cavity and mostly having a thick clustered appearance; they often possess a thinner stalk attaching them to the cell wall. They are always strongly impregnated with calcium carbonate. *Ficus elastica*, cells of water tissue of leaf; *Cannabis sativa*, hairs of leaf. Confer S. No. 523.

S. No. 546. (cf. S. No. 525). Collenchymatous thickenings. Walls principally thickened in the corners of the cells, where more than 2 cells come together. When the rest of the cell walls is also thickened the cell cavity often exhibits a rounded shape, whilst the form of the whole cell is polygonal. These thickenings have a peculiar brilliant appearance and mostly exhibit a very conspicuous cellulose reaction. Subepidermal layers in many stems and veins of leaves.

S. No. 547. (cf. S. No. 524). The centrifugal relief figures are al formed by cutin or wax, confer S. No. 522. We may distinguish:
1a. cuticular striation. Fine ridges on the outside of the cuticle often independent of the outlines of the underlying cells in direction, place and size; often more or less undulating; arranged irregularly, radiating or parallel.
1b. small warts and knobs on the cuticle. Often occurring on the surface of file hairs.
1c. protuberances on the exosporium of spores and the exine of dicotyledonous pollen grains. In the form of spines (*Malva, Uredo, Tuber*), ridges (*Cucurbita*), reticulations (*Lycopodium*), bands of peculiar structure etc.

S. No. 548. (cf. S. No. 515). Perforation in cell walls. We may distinguish:
1a. ordinary perforations. Water tissue of *Sphagnum.*
1b. perforations of the transverse partition walls in xylem vessels. They are formed by the disappearance of the closing membranes of large perforation-pits, either simple or mostly bordered and in the latter case showing only small difference in width between the halo and the not widened pit-aperture. See S. No. 573.
1c. sieve pores. Fine perforations in the transverse partition walls or lateral walls of sieve tubes and perhaps in some xylem vessels, though doubts have risen recently about it (cf. S. No. 539). They are clustered together in smaller or larger numbers on areas called sieve plates.
1d. perforations through which the plasmodesms (cf. S. No. 469) pass from one protoplast to another. They are mostly confined to the closing membranes of pits, sometimes however penetrating the whole thickness of the cell wall.

S. No. 549. (cf. S. No. 515). Schizogenous intercellular spaces. Cavities between the cells; they are mostly filled with air and arise in the middle lamella and in the gussets, by the action of tensions in consequence of turgor etc., when pectin substances in the middle lamella have passed into a fluid state (cf. S. No. 522 pectin). Within the intercellular spaces remnants of those pectin substances are often to be found and may be distinguished as:
1a. connecting frames (cadres d'union of Mangin). Filling

up the corners of the intercellular spaces and surrounding those parts of the cell walls common to adjacent cells. *Citrullus Colocynthis*, pulp of the fruit.

1b. rodlets (bâtonnets of Mangin). Fine, more or less cylindrical processes protruding into the intercellular spaces. *Equisetum arvense,* cortical parenchyma.

See moreover S. No. 634.

S. No. 550. (cf. S. No. 456). Turgor and plasmolysis. Turgor, turgidity or turgescence is the mechanical tension mostly existing between the living protoplast and the elastic cell wall. Cells in this state are called turgescent or turgid. When by absorption of water turgor appears, the cell becomes larger, more rigid, often at the same time being modified in shape. As turgor is the result of hydrostatic pressure, it disappears if water is lost for instance by evaporation; the cell wilts, returning to its original size and shape and becoming flaccid and soft.

Plasmolysis. If a turgescent cell is surrounded by a solution of harmless substances which are unable to permeate the protoplasm, and if this solution shows a higher osmotic pressure than the cell sap, water is withdrawn from the cell, turgor is weakened and the cell contracts by the elasticity of the cell wall.

Turgor has disappeared when this collapse is at an end. Then further contraction of the protoplast ensues and this is called plasmolysis. See S. No. 551.

S. No. 551. (cf. S. No. 550). In plasmolytic experiments some harmless dye is mostly added to the solution mentioned above in order to distinguish living from dead protoplasm. Two kinds of plasmolysis may be distinguished:

1a. normal plasmolysis, plasmolysis proper. The parietal cytoplasm is separated from the cell wall and the protoplast takes as much as possible the form of a sphere. This contraction continues until the osmotic pressure in the protoplast has reached the same value as that of the surrounding solution which penetrated through the cell wall and fills the space between it and the contracted protoplast. Often very fine protoplasmic threads extend from the protoplast to the cell wall. If the solution causing plasmolysis is removed and replaced by water, the protoplast expands, is soon again united to the cell wall and turgor reappears.

1b. abnormal plasmolysis.

If plasmolysis is caused by a more sudden withdrawal of water for instance in a plasmolysing solution of a higher osmotic pressure, ectoplasm, middle layer of the parietal cytoplasm, cell nucleus and plastids often die at once and more or less remain in their places, whilst the tonoplast remains in a living state and contracts in the same manner as the whole parietal cytoplasm in normal plasmolysis. Thus the vacuoles with their contents are isolated, often at the same time being divided into two or more parts.

In many cases the dying process of the outer parts of parietal cytoplasm may be slower, so that at first normal plasmolytic contraction takes place.

Thus all transitions may appear from abnormal plasmolysis, in which the dead outer parts of the cytoplasm have fairly well retained their original places, to that in which a complete normal plasmolysis has preceded the death of those outer parts, now closely enveloping the living tonoplast bladder.

Aggregation of protoplasm is a phenomenon discovered by Darwin in insectivorous plants and shows a certain relationship to abnormal plasmolysis, though it takes place in living cells. Under the influence of various stimuli the sap cavity contracts and is divided into a large number of tonoplast bladders, which circulate through the cell by means of the streaming motions of living protoplasm; the original state finally returns.

§ 2. Histology (cf. S. No. 455).

S. No. 552. Histology may be divided into two parts:
1a. General Histology. It comprises descriptions of the histological structure and of the technical terms which are used in them, in so far as both are not limited to special forms or special organs of external organisation. See S. No. 533.
1b. Special Histology. It comprises descriptions of the histological structure and of the technical terms which are used in them, in so far as both are limited to special forms or special organs of external organisation, like thallomes, cormi, roots and appendages of the surface. See S. No. 710.

A. General Histology.

S. No. 553. (cf. S. No. 552). In general histology the following subjects will be dealt with:
1a. cellular elements constituting tissues. See S. No. 554.
1b. tissues. See S. No. 615.

S. No. 554. (cf. S. No. 553). Cellular elements constituting tissues. Concerning cellular elements the following subjects will be dealt with:
1a. general survey. See S. No. 555.
1b. special cellular elements appearing in secondary xylem and phloem. See S. No. 584.

S. No. 555. (cf. S. No. 554). Among the cellular elements constituting tissues we may distinguish:
1a. single cells. See S. No. 556.
1b. vessels. Elements arising from the fusion of single cells which are placed in a row; the cell walls separating these cells entirely or partly disappear and cylindrical or prismatical tubes are formed which may attain a very considerable length and sometimes may be branched. See S. No. 568.

S. No. 556. (cf. S. No. 555). Concerning single cells the following subjects will be dealt with:
1a. grade of differentiation. See S. No. 557.
1b. external shape. See S. No. 558.
1c. characters of the cell wall. See S. No. 560.
1d. substances occurring in the cell-cavity. See S. No. 566.
1e. the secretion of peculiar substances. See S. No. 567.

S. No. 557. (cf. S. No. 556). With respect to the grade of differentiation we may distinguish:
1a. meristem cells or meristematic cells. Showing the lowest grade of differentiation of which they are capable. See S. No. 619.
1b. permanent, fixed or mature cells. Showing the highest grade of differentiation belonging to them. These cells when active, are only exceptionally in a state of division and consequently they show in particular cases only, nuclear division and recently formed partition-walls. Most, but not all of them develop from meristematic cells.

S. No. 558. (cf. S. No. 556). With respect to external shape we may distinguish:
1a. parenchymatic elements. Showing no pointed ends, except in the case of the end-cells of a row of parenchymatic elements formed by division of a fibre (wood parenchyma, crystal fibres). For the rest, if unbranched, they may show all shapes from isodiametrical (spheres, polyhedra) to much elongated cylinders, prisms or filaments: they may be branched or septate; if pitted the pits have not a strong tendency to be slit-like or conspicuously arranged in spirals; intercellular spaces may be wanting but may also occur in all grades of development; their contents may be of all possible kinds. See S. No. 559.
1b. prosenchymatic elements or fibres. Showing two or more pointed ends, either one- or two-sidedly tapering (cambium fibres) or conical. For the rest they are mostly spindle-shaped and in a transverse section circular or polygonal; they sometimes show a thicker more or less well defined middle part and much thinner ends; they may be branched, (*Euphorbia splendens*, latex cells; *Camellia japonica*, sclereids in mesophyll of leaf); they may be septate and in these cases the partition-walls are generally extraordinarily thin; if pitted the pits have a strong tendency to be slit-like and spirally arranged; intercellular spaces are mostly wanting and never strongly developed; their contents are of various kinds but mostly less differentiated than those of parenchymatic elements. *Theobroma cacao*, fruit, inner epidermis of pulp; tracheids and libriform-fibres.

S. No. 559. (cf. S. No. 558). Parenchymatic elements may be divided with respect to shape, arrangement and mode of development, into:
1a. parenchyma cells. From isodiametrical to more or less

elongated (globular, cylindrical, prismatical, etc.); now and then branched (spongy mesophyll of many leaves; *Juncus*, medulla of stem); in some cases septate (cells of cortex in stems); walls mostly pitted, further all other kinds of relief figures may occur; in intimate contact with one another, but often showing numerous and sometimes very large intercellular spaces.

1b. hyphae. Filaments often of considerable length, either non-septate (*Mucor*, mycelium) or septate (*Eumycetes*, *Chondrus crispus*, *Fucus*, thallus); they are often branched (*Penicillium*, mycelium); walls sometimes pitted, but other kinds of relief figures are very scarce; generally not in intimate contact with one another or even loosely interwoven; intercellular spaces often occurring but generally not very spacious. In some cases we may distinguish:

2a. pseudoparenchymatic elements. Filaments in intimate contact and divided into short cells. *Claviceps purpurea*, sclerotium; *Cetraria islandica*, cortical layers.

S. No. 560. (cf. S. No. 556). Concerning the characters of the cell-wall of single cells the following subjects will be dealt with:

1a. thickness. See S. No. 561.
1b. cell wall substances. See S. No. 562.
1c. relief figures. See S. No. 563.
1d. foldings. See S. No. 564.
1e. absciss-cells. See S. No. 565.

S. No. 561. (cf. S. No. 560). With respect to the thickness of the cell walls we may distinguish:

1a. thin-walled elements.

2a. thin-walled parenchyma cells, which may be called common parenchyma cells. *Sambucus nigra*, medulla of stem; pulp of many fruits.

2b. thin-walled fibres. Many cambial elements; *Taxus*, bast fibres in young branches; *Theobroma cacao*, pulp of fruit, inner epidermis.

1b. collenchymatous elements. Provided with collenchymatous thickenings of the walls (cf. S. No. 546). The differentiation of these elements takes place at an early stage of development, when they are still growing; they show well developed protoplasts and often chloroplasts; their walls generally lack stratification and are sometimes pitted; intercellular spaces often wanting, but in other cases well developed; they are generally to be found in the neighbourhood of the surface of the parts containing them, e.g. in the outer cortical layers of many stems. In connection with their external shape we may distinguish:

2a. collenchymatous parenchyma cells. Cortex of many stems; *Erythraea*, anther, epidermis on line of dehiscence; *Arnica montana*, filament, epidermis of so-called articulation.

2b. collenchyma fibres.

1c. sclerenchymatous elements. Their walls show sclerenchymatous thickening (cf. S. No. 517). These elements are often differentiated in the later stages of development of the parts containing them; in the adult state their cavities are often filled with air; their walls mostly show stratification; they show several kinds of relief figures and especially pits, simple or bordered, if simple often branched; intercellular spaces are mostly wanting. In connection with their external shape we may distinguish:

2a. sclereids, sclerenchyma cells or stone-cells. Parenchymatous elements. Stones of many fruits.

2b. sclerenchyma fibres. *Cinchona,* secondary phloem; *Linum usitatissimum,* pericyclic fibres; libriform fibres in secondary xylem.

S. No. 562. (cf. S. No. 560). With respect to the character of the cell-wall substances we may distinguish:

1a. cuticularised cells. Their free surface walls are provided with a cuticle, often also with cuticular layers (cf. S. No. 522); they often show centrifugal relief figures. Many epidermal cells, spores, pollen grains and massulae.

1b. periderm cells. They possess a suberin lamella, formed by the secondary layers of the cell-wall and in this part of the wall pits are wanting. These cells have mostly the shape of prismatic parenchyma cells, but may be flattened afterwards into discs; their walls parallel to the surface of the part containing them, may be thickened, either the outer (*Croton Eluteria*; *Larix europaea*), or the inner ones (*Aesculus rubicunda*; *Punica Granatum*); their walls with the exception of the suberin lamella, are often lignified and often entirely coloured brown; in their permanent state they are mostly dead, their contents consisting of air and masses of a brown colour, often containing tannin; intercellular spaces are generally wanting except in lenticels (see S. No. 664). Primary and secondary cork tissues.

1c. cells of protective sheath. They are common parenchyma cells, characterised by a narrow strip of lignified and corky matter in their cell-walls; this strip appears in the walls placed transversely and radially with respect to the longitudinal axis of the sheath formed by these cells and entirely surrounds them in a tangential plane, often causing folds in those walls and giving rise in transverse sections to the so called Casparian dots, in tangential sections appearing as a wavy band. In a later stage these cells develop into periderm cells by the formation of a complete suberin lamella and in a still later stage they may even develop into sclereids. *Vicia Faba,* endodermis of root; *Radix Sarsaparillae* and *Dendrobium nobile,* aerial root, both with sclerotic endodermis.

1d. mucilage cells. Characterised by mostly very strong thickenings of the walls or parts of them; the deposited cell wall substances swell up in water. *Althaea officinalis,* leaf, epidermal cells; *Tilia,* bract, mesophyll; *Linum usitatissimum,* seed-coat, epidermis.

1e. stegmata or covering plates. Characterised by outgrowths of the cell-walls, impregnated with silica (cf. S. No. 523). Sheaths round the fibrovasal bundles of *Palms* and *Ferns*.

S. No. 563. (cf. S. No. 560). With respect to the relief figures of the cell-walls (see S. No. 525) we may distinguish:
1a. pitted cells and fibres.
2a. with simple pits. The majority of common parenchyma cells.
2b. with bordered pits. Tracheid fibres (*Pinus*, wood); among cells occurring only in a few cases, viz in cells of transfusion tissue (*Pinus*, leaf) see S. No. 637.
1b. annular and spiral cells and fibres. *Sphagnum*, leaf; *Mamillaria echinata*, secondary xylem; *Marchantia polymorpha*, elaters; *Taxus baccata*, wood, tracheid fibres.
1c. reticulate cells. *Dendrobium nobile*, aerial root, velamen.

S. No. 564. (cf. S. No. 560). Cells with infolded walls. In several cases folds are formed by unequal growth in area of the cell-walls; these folds protrude into the cavity of the cell, but without dividing the cell into separate chambers. *Spirogyra*, transverse walls; *Pinus*, leaf, chlorenchyma in mesophyll; *Characeae*, globule, scutella.

S. No. 565. (cf. S. No. 560). Absciss-cells. They are parenchymatic cells which in a mature state are separated from one another, in consequence of which certain organs, like deciduous leaves, twigs and fruits may be thrown off. *Aesculus hippocastanum*, fall of the leaf; *Populus balsamifera*, dehiscent twigs; *Carum carvi*, dehiscent mericarps of fruits [1]).

S. No. 566. (cf. S. No. 556). With respect to the occurrence of certain characters belonging to the contents of the cell-cavity numerous kinds of cells may be distinguished. Some of the most important are the following:
1a. chlorenchyma cells. Parenchyma cells containing a large number of small or a small number of large chloroplasts. Mesophyll of many leaves; many *Conjugatae*.
1b. water-reservoir or water-storage cells. They are able to contain a large amount of water, that may be yielded to other cells in their vicinity under certain circumstances. We may distinguish:
2a. living water-reservoir cells. Colourless common parenchyma cells with cellulose walls and without plastids; intercellular spaces wanting or small. *Ficus elastica*, leaf, mesophyll.
2b. dead water-reservoir cells. Annular, spiral or reticulate parenchyma cells with lignified relief figures and sometimes

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[1]) Drs. M. A. J. Goedewagen en Dr. K. Zijlstra. Gewone, loszadige karwij en een nieuwe zaadhoudende variëteit. Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations, 30, the Hague, 1925, p. 287.

showing perforations in their walls; contents water and air or both together. *Sphagnum*, leaves; *Dendrobium nobile*, aerial roots, velamen.

1c. aleurone cells. Containing aleurone grains. *Ricinus communis*, endosperm; *Acacia sphaerocephala*, food-bodies at the tops of leaflets.

As special kind of these cells we may distinguish:

2a. gluten cells. Containing minute aleurone grains in very large numbers. *Hordeum vulgare*, endosperm.

1d. starch cells. *Solanum tuberosum*, tuber parenchyma.

1e. sugar cells. *Beta vulgaris*, root, parenchyma; *Pyrus communis*, fruit, pulp.

1f. oil cells. Containing either fatty oil (*Linum usitatissimum*, cells of cotyledons), or ethereal oil (*Myristica fragrans*, endosperm; *Acorus Calamus*, rhizome, idioblasts).

1g. inulin cells. *Inula Helenium*, root, parenchyma cells.

1h. tannin cells. *Acorus Calamus*, rhizome, idioblasts; oak galls, parenchyma cells.

1i. anthocyanin cells. Containing anthocyanin either in solution or in a solid state. *Fagus sylvatica*, *var. rubra*, leaf, epidermal cells; corolla of many flowers; red cabbage.

1j. enzyme cells. *Prunus Laurocerasus*, leaf, endodermis; *Sinapis nigra*, myrosin cells, cotyledons.

1k. alkaloid cells. *Conium maculatum*, pericarp, inner epidermis, called coniine layer.

1l. mucilage cells. *Orchis Morio*, tuber, idioblasts. *Urginea Scilla*, bulb scales, rhaphide cells.

1m. latex cells. *Ipomoea Purga*, root. Latex fibres: *Euphorbia splendens*. Hyphal tubes containing latex: *Lactarius deliciosus*, fructification.

S. No. 567. (cf. S. No. 556). Glandular cells are cells producing and excreting special substances, often in a fluid state, but not water only (see S. No. 647, emissaries). *Pinus*, wood, epithelium of resin ducts.

S. No. 568. Vessels (cf. S. No. 555). Concerning vessels the following subjects will be dealt with:

1a. articulations and partition-walls. See S. No. 569.

1b. kinds of vessels. See S. No. 571.

S. No. 569. (cf. S. No. 568). In vessels we may distinguish:

1a. articulations. The parts corresponding to the original cells which by fusing together have produced the vessel.

1b. partition-walls. The cell-walls between the articulations; they may have disappeared altogether or show perforations in various numbers, kinds, dimensions and shapes. See S. No. 570.

S. No. 570. (cf. S. No. 569). Partition-walls, with respect to the direction in which they are placed, may be distinguished as:

1a. horizontal. At right angles to the longitudinal axis of the vessel.
1b. oblique. Slanting with respect to the longitudinal axis of the vessel.

S. No. 571. (cf. S. No. 568). With respect to shape, structure of the walls and contents of the cavity we may distinguish:
1a. xylem vessels or tracheae. See S. No. 572.
1b. sieve tubes or phloem vessels. See S. No. 579.
1c. latex vessels, formerly called vasa propria. See S. No. 582.
1d. tannin vessels. See S. No. 583.

S. No. 572. (cf. S. No. 571). Concerning xylem vessels the following subjects will be dealt with:
1a. meaning of the term. See S. No. 573.
1b. partition walls. See S. No. 574.
1c. relief figures. See S. No. 578.

S. No. 573. (cf. S. No. 572). Xylem vessels, the chief tracheal elements. They are cylindrical or prismatical tubes mostly wider than the surrounding elements and always much longer, long even up to several meters (*Calamus spp.*); seldom branched. Walls more or less thickened and lignified, always provided with relief figures (cf. S. No. 524); partition-walls having entirely disappeared (most spiral vessels) or perforated by the disappearence of the closing membrane of large simple or bordered perforation-pits (cf. S. No. 548). Contents: no well developed parietal protoplasm or cell-nuclei and plastids; sometimes water, sometimes air, generally under a less than atmospheric pressure, in other cases again water, intermixed with air-bubbles; sometimes the cavity is more or less filled up with thyloses (see S. No. 603).

Articulations of vessels not provided with perforations, sometimes showing perforation only at one end are called vascular or vessel tracheids. Many *Filicineae*; *Microtropis bivalvis* and *Shorea Javanica*, wood; spiral tracheids in the veinlets of many dicotyledonous leaves.

S. No. 574. (cf. S. No. 572). Concerning partition walls the following subjects will be dealt with:
1a. shape of perforations. See S. No. 575.
1b. margins of perforations. See S. No. 576.
1c. ordinary closed bordered pits. See S. No. 577.

S. No. 575. (cf. S. No. 574). Perforations of the partition-walls of xylem vessels may be:
1a. circular or oval. Partition-wall mostly with a single circular or oval perforation; seldom showing a larger number of perforations of the same kind. In the large majority of horizontal or only slightly oblique partition-walls. *Quassia amara*, wood.
1b. scalariform. Partition-wall with several, often numerous

slit-like perforations, placed mostly in a vertical, sometimes in a horizontal row. Almost exclusively in oblique, seldom in horizontal partition-walls. The portions of the partition-wall remaining between the perforations are called steps; they may be sometimes branched or united together by transverse bars. *Viburnum Opulus*, wood; *Polyosma integrifolia*, wood. [1])

S. No. 576. (cf. S. No. 574). The margins of the perforations may be:
1a. smooth. Perforations have been formed in simple perforation-pits. *Tetrameles nudiflora.*
1b. bordered-pit-like. Consisting of 2 lamellae diverging at an acute angle; the perforations have been formed in bordered perforation-pits (cf. S. No. 548). *Dalbergia latifolia.*

S. No. 577. (cf. S. No. 574). Especially in oblique partition-walls there occur sometimes in addition to the perforations ordinary closed borderd pits (*Macropanax oreophilum*); in the case of scalariform perforations those bordered pits may be sometimes arranged in rows corresponding in place to the slits of the neighbouring scalariform perforation (*Nyssa sessiflora*).

S. No. 578. (cf. S. No. 572). With respect to the relief figures on the walls of xylem vessels and vascular tracheids we may distinguish:
1a. annular vessels. *Zea Mays*, stem, protoxylem.
1b. spiral vessels. Primary xylem of many organs. *Musa sp.*, petiole.
1c. reticulate vessels. Primary xylem of many organs.
1d. pitted vessels. They are provided with pits, almost exclusively with bordered. Nevertheless in a very few cases simple pits may occur in addition to bordered pits, though mostly restricted to areas of the wall adjoining wood parenchyma cells or cells of medullary rays [2]). *Aphanomyrtus tetraquetra* and other *Myrtaceae*, secondary xylem.

With respect to the shape and arrangement of the bordered pits we may distinguish:

2a. scalariform vessels. Mostly prismatic vessels showing on their sides strongly elongated slit-like pits placed near to one another in a longitudinal row, the slits themselves being directed perpendicularly to the longitudinal axis of the vessel. *Pteris aquilina*, leaf, meristeles.

S. No. 579. (cf. S. No. 571). Concerning sieve tubes the following subjects will be dealt with:
1a. meaning of the term. See S. No. 580.
1b. sieve plates. See S. No. 581.

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[1]) Moll and Janssonius. Mikrogr. d. Holzes. Bd. III, Leiden 1918 p. 289.

[2]) Moll and Janssonius. Mikrographie d. Holzes, confer indices of volumes, sub Gefäszwände.

S. No. 580. (cf. S. No. 579). Sieve-tubes or phloem vessels, the cribral elements. They are cylindrical or prismatical tubes; mostly narrower than xylem vessels, and not much wider than the surrounding elements, companion cells excepted, and often of considerable length. Walls generally not much thickened, lignification generally and relief figures always wanting; partition-walls entirely disappeared (*Gymnospermae*), or present and provided with sieve-plates (cf. S. No. 548). Contents: living protoplasm but with obliterated cell nuclei, often starch grains; mostly a considerable amount of more soluble albuminous substances; in the ordinary course of anatomical investigations the partition-walls are found to be covered on one side by a more or less voluminous so called callus plate, an artificial product, arising when the plant is wounded.

In many cases a longitudinal wall is formed in each articulation and thus thin parenchyma cells, sister cells of the articulations ensue, called companion cells with living contents and well developed cell-nuclei. The formation of sieve tubes from meristematic cells is often preceded by longitudinal divisions of those cells, so that a bundle of sieve-tubes may arise from one row of mother-cells. This may be the case in the formation of primary phloem bundles (*Olea europaea*, petiole, *Euphorbia caput Medusae* [1])) and also in that of secondary phloem from cambium fibres (*Nerium Oleander, Asclepias curassavica* [2]); *Cochlearia Armoracia*, rhizome and *Oenothera biennis*, root [3]); *Cochlearia Armoracia*, root [4])). Examples of sieve tubes arising without preceding longitudinal divisions of the mother cells are afforded by *Gymnospermae* and many *Angiospermae*, for instance *Betula alba*, secondary phloem of stem; moreover with companion cells by *Zea Mays*, fibrovasal bundle of stem and *Cucurbita Pepo*, stem.

S. No. 581. (cf. S. No. 579). In sieve tubes sieve plates may occur:
1a. on the lateral walls. In this case they are mostly circular or slightly oval. *Gymnosperms*, secondary phloem; *Filices*, meristeles; *Cucurbita Pepo*, stem.
1b. on the partition-walls. In this case they may be:
2a. circular or slightly oval. Mostly one, sometimes a few in number. In the large majority of horizontal or only slightly oblique partition-walls. *Cucurbita Pepo*, stem; *Gentiana lutea*, root, secondary phloem.
2b. strongly elongated, numerous and arranged like the scalariform perforations in xylem vessels. This may be called scalari-

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[1]) De Bary, Vergl. Anat. d. Vegetationsorgane, Leipzig 1877, p. 337.

[2]) De Bary, l.c. p. 539.

[3]) J. E. Weiss, Anatomie und Physiologie fleischig verdickter Wurzeln, Flora 63, 1880, p. 83 and p. 98.

[4]) J. J. Beyer, Die Vermehrung der radialen Reihen im Cambium, Recueil Trav. bot. néerl. 24, 1927, p. 732.

form arrangement of the sieve-plates. Almost exclusively in oblique partition-walls. *Vitis vinifera,* stem.

S. No. 582. (cf. S. No. 571). Latex vessels. They are mostly cylindrical and often strongly branched and anastomosing with one another. Walls not much thickened, lignification and relief figures wanting, partition-walls having entirely or almost entirely disappeared. Contents: living protoplasm with well developed cell-nuclei; the sap-cavity contains latex, an emulsion, white or coloured. *Papaver somniferum* (white); *Chelidonium majus* (yellow); *Sanguinaria officinalis* (red).

S. No. 583. (cf. S. No. 571). Tannin vessels[1]). They are mostly short and not branching or anastomosing. Walls not thickened; partition-walls perforated in the middle, a diaphragm remaining. Sap-cavity filled with a fluid containing tannin. *Angiopteris evecta,* root and petiole; *Marattia attenuata,* root.

S. No. 584. (cf. S. No. 554). Special cellular elements appearing in secondary xylem and phloem. Concerning these special cellular elements the following subjects will be dealt with:
1a. common fundamental shape of the elements forming secondary xylem and phloem. See S. No. 585.
1b. common differentiation of the elements forming secondary xylem and phloem. See S. No. 586.
1c. secondary xylem. See S. No. 587.
1d. secondary phloem. See S. No. 605.

S. No. 585. (cf. S. No. 584). The fundamental shape of all elements which constitute secondary xylem and phloem is represented by that of a fibre. This is the consequence of the fact that both tissues are thrown off by a common meristematic layer, the cells of which in the great majority of cases are simple and elongated fibres; this meristem is the cambium which will be fully dealt with below (see S. No. 620). In many cases the fibrous form is retained in the mature state, though in other cases it may be less conspicuous and in a few has even disappeared altogether.

S. No. 586. (cf. S. No. 584). The differentiation of the elements constituting secondary phloem and xylem is of course in many respects very different. Nevertheless in both cases they may be referred to three classes or types showing a certain relationship. In this respect we may distinguish:
1a. a class of elements characterized by the predominance of vessels. Elements of the cribral class in phloem, of the tracheal class in xylem.

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[1]) Cyril West. On the structure and development of the secretory tissues of the *Marattiaceae.* Ann. of Bot. 29, 1915, p. 419.

1b. a class of elements characterized by the predominance of thick-walled sclerenchyma fibres. The class of bast fibres in phloem, of libriform fibres in xylem.
1c. a class of elements characterized by the predominance of parenchyma cells. The class of bast parenchyma in phloem, of wood parenchyma in xylem.

Moreover both secondary phloem and xylem may contain idioblasts and internal glands of several kinds.

S. No. 587. (cf. S. No. 584). Secondary xylem. Concerning secondary xylem the following subjects will be dealt with [1]:
1a. special characters of the xylem elements in contrast with phloem elements. See S. No. 588.
1b. classes of elements. See S. No. 589.
1c. idioblasts. See S. No. 601.
1d. conjugated or copulated elements. See S. No. 602.
1e. thyloses. See S. No. 603.
1f. reciprocal character of pits belonging to adjoining elements. See S. No. 604.

S. No. 588. (cf. S. No. 587). The following characters may be mentioned as belonging to the elements of secondary xylem in contrast with those of secondary phloem:
1a. all elements are generally more or less and often strongly sclerotic, although cases of herbaceous xylem occur (*Daucus Carota*, root).
1b. the cell cavity often contains water or air or both together.
1c. the cell walls of older elements are often more or less strongly coloured.
1d. bordered pits occur in the walls of many elements.

S. No. 589. (cf. S. No. 586 and 587). The following classes of elements may be distinguished:
1a. tracheal elements. During their development from cambium fibres they mostly show only a very slight longitudinal growth, though a transverse growth may not be wanting; moreover they never become septate by the formation of cross walls. They exhibit various shapes, mostly have a large cavity, and relatively thin walls rarely showing a gelatinous layer. Their walls are abundantly pitted; on their sides the occurrence of bordered pits is preponderating, though simple pits are not entirely wanting. Spiral bands are often to be found. They contain in fresh wood water or water and air, in dry wood only air; afterwards often various substances sometimes having a resinous nature and often covering the walls. See S. No. 590.

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[1] I received in July 1933 a printed communication from the International Association of Wood Anatomists written by the Secretary-Treasurer Mr. Samuel J. Record. A part of this communication is entitled "Committee on Terminology". I draw the attention of my readers to this fact, but as no particulars are mentioned, I was not in the position to judge whether any alternation in the terminology proposed in the text might be desirable.

1b. libriform elements. During their development from cambium fibres they often show an abundant longitudinal sliding growth but no transverse growth of any importance; moreover they may sometimes become divided into cells by cross walls. They are fibres mostly with a small cavity; and relatively thick walls rather often showing gelatinous layers. Pits in the walls relatively rare, sometimes wanting; if present, the pits are either simple or bordered, all pits are slit-like and arranged obliquely sinistrorse; the bordered pits differing in size and shape from those of the tracheal elements, generally smaller and the borders always about circular. Spiral bands always wanting. Libriform elements, with simple pits and in very rare cases (*Lignum Sassafras*) those provided with bordered pits, contain in fresh young wood living protoplasm and often starch, those with bordered pits generally air and water; in dry wood only air and afterwards sometimes coloured substances. See S. No. 594.

1c. parenchymatic elements. During their development from cambium fibres they mostly show no longitudinal and transverse growth, moreover they are mostly divided into cells by cross walls but nevertheless in most cases the original fibres remain discernible. They mostly have a wide cavity and relatively thin walls without a gelatinous layer. Their walls are abundantly pitted with always simple pits. Spiral bands wanting though they may appear in very exceptional cases (*Lasianthus purpureus*) [1]). They contain in fresh young wood living protoplasts and often starch, tannin, crystals, etc. See S. No. 595.

S. No. 590. (cf. S. No. 589). Concerning tracheal elements the following subjects will be dealt with:
1a. their kinds with respect to shape. See S. No. 591.
1b. their kinds with respect to relief figures. See S. No. 592.

S. No. 591. (cf. S. No. 590). Among tracheal elements we may distinguish with respect to their shape:
1a. vessels. They exhibit no gelatinous layer. Confer S. No. 573.
1b. tracheids. Each of them has been developed from a single cambial fibre. They may have the shape either of articulations of vessels or of fibres. See S. No. 593.

S. No. 592. (cf. S. No. 590). With respect to the relief figures of the walls we may distinguish:
1a. pitted vessels. Confer S. No. 578.
1b. scalariform vessels. Confer S. No. 578.

S. No. 593. (cf. S. No. 591). Among tracheids we may distinguish:
1a. vessel tracheids or vascular tracheids. They are to be found in the vicinity of vessels; they are relatively short, show rounded ends, and no gelatinous layer.

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[1]) Moll and Janssonius. Mikrographie d. Holzes, 4, Leiden 1920, p. 243.

1b. fibre tracheids, tracheid fibres or fibrous tracheids. They are to be found at some distance from the vessels: they are mostly longer than the vascular tracheids, moreover thicker walled and less abundantly pitted; they are shorter than the libriform fibres but sometimes it is difficult to distinguish them from one another; they never show cross walls but sometimes are provided with transverse bars. Confer S. No. 544. Most *Gymnospermae.*

S. No. 594. (cf. S. No. 589). Among libriform elements we may distinguish:
1a. ordinary or non-septate libriform fibres.
1b. septate libriform fibres. They are divided into cells by one or more thin unpitted cross walls; their side walls almost without exception show simple pits; they almost always contain starch in slight quantity, sometimes also crystals.

S. No. 595. Concerning parenchymatic elements the following subjects will be dealt with:
1a. the kinds of parenchymatic elements. See S. No. 596.
1b. medullary ray cells. See S. No. 598.

S. No. 596. (cf. S. No. 595). Among parenchymatic elements we may distinguish:
1a. wood parenchyma cells. These cells are formed not by initial cells of the cambium, but by segments thrown off by those initial cells, so that the same initial cell can afterwards produce also elements belonging to another class. They arise from the segments in consequence of cross divisions, but the shape of these fibres often remains discernible and thus wood parenchyma fibres are formed; the partition cells have the shape of oblong 4- to 8-sided prisms with longitudinally directed axis and sometimes rounded edges; where these elements are adjoining one another their walls show in a very few cases slit-like, but mostly only circular or almost circular pits; these pits are most abundant on the transverse walls, and on the radial walls they are mostly arranged in groups. Intercellular spaces may occur. See S. No. 597.

2a. substitute wood parenchyma fibres or fibrous cells. These elements have mostly the shape of fibres; they are developed from cambial segments without cross divisions; their length is the same as that of the wood parenchyma fibres of the same plant. Where these elements are adjoining one another their walls show either circular or slit-like oblique sinistrorse pits. *Pterocarpus santalinus* and *Viburnum Lantana,* stem; *Cochlearia Armoracia,* root.
1b. medullary ray cells. These elements arise from cambial initial cells which are divided themselves by transverse walls into cells, so that the same initial cell does not afterwards produce elements belonging to any other class. The shape of the original cam-

bium fibre may be found back more or less in the tangential section of the medullary ray. The shape of the cells is that of a 4- to 8-sided prism often with rounded edges. Their tangential walls are mostly very thick and abundantly pitted. Intercellular spaces occur very often. See S. No. 598.

S. No. 597. (cf. S. No. 596). With respect to the distinctness of the original fibrous form we may distinguish:
1a. irregular wood parenchyma. The shape of the cambial fibres has been entirely lost. *Sparmannia africana.*
1b. regular or fibrous wood parenchyma. The original wood parenchyma fibres may be identified.

S. No. 598. (cf. S. No. 595 and 596). Concerning medullary ray cells the following subjects will be dealt with:
1a. their several shapes. See S. No. 599.
1b. ray-tracheids. See S. No. 600.

S. No. 599. (cf. S. No. 598). Among medullary ray cells we may distinguish:
1a. procumbent or horizontal cells. They often constitute broad pluriseriate layers. Their largest diameter is radially directed, they have generally somewhat thicker walls than the erect cells. They exhibit narrow intercellular spaces mostly extending in a radial direction; the pits sometimes lead towards these intercellular spaces. Confer S. No. 528.
1b. erect, vertical or upright cells. They mostly constitute uniseriate layers. Their largest diameter is longitudinally directed. Radial intercellular spaces are mostly wanting.
1c. tile-shaped cells. Their smallest diameter is radially directed; contents are mostly wanting. *Durio zibethinus, Neesia altissima, Reevesia Wallichii, Kleinhovia hospita.*[1])

S. No. 600. (cf. S. No. 598). Tracheidal medullary ray cells or ray-tracheids having bordered pits and exhibiting other characters of the elements of the tracheal class, are to be found in some Gymnosperms. *Pinus.*

S. No. 601. (cf. S. No. 587). Idioblasts of various kinds are often to be found in secondary xylem, for instance crystal cells, oil cells (*Magnoliaceae*, stem; *Sassafras officinale*, root), mucilage cells (*Nectandra*, stem[2])), enzyme cells (*Cochlearia Armoracia*, root). They belong mostly to the parenchymatic class of elements (in *Cochlearia Armoracia* substitute fibres), sometimes to the libriform class (crystal cells).

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[1]) Moll and Janssonius. Mikrogr. d. Holzes. Bd. I Leiden 1906, p. 408, 412, 457, 461.

[2]) H. H. Janssonius. Mikrographie einiger technisch wichtigen Holzarten aus Surinam, Verhand. Kon. Akad. Amst. 2nd Sect. 18, 2, 1914; see on p. 46.

S. No. 602. (cf. S. No. 587). Conjugated or copulated elements. If elements occur contiguous to or in the vicinity of vessels, which have become very wide by growth in thickness, they often show flat tubular processes on their lateral walls. The processes of adjoining cells meet one another, are sometimes branched or may have blind ends not meeting other processes. The spaces between these tubular processes are sometimes filled with thickening masses of the cell walls but in most cases with outgrowths of neighbouring elements. Those processes are called conjugation-tubes. They occur mostly among elements of the parenchymatic class: wood parenchyma cells: *Dillenia aurea*; medullary ray cells and among the latters only in erect cells: *Ternstroemia macrocarpa*; among the elements of the tracheal class they occur now and then but only in vascular tracheids. Conjugated elements are nearly related to those of spongy tissue. See S. No. 635.

S. No. 603. (cf. S. No. 587). Thyloses are parenchyma cells more or less filling up the cavity of vessels or other dead elements, sometimes of intercellular spaces. They arise by growth of surrounding parenchyma cells bulging out into the cavity through pits. They grow out in the cavity at first in a spherical form and often become polyhedral when meeting other thyloses in the same cavity. At last they are separated from their mother-cell by a partition wall in the thin part where they entered into the cavity. Their cell walls are mostly thin, sometimes sclerenchymatous, often lignified and mostly provided with simple pits. *Fraxinus excelsior* and many other woods.

S. No. 604. (cf. S. No. 587). The reciprocal character of pits abutting on one another in elements of the same and of different classes. In the tracheal class of elements one and the same element may exhibit pits of different characters in different parts of its wall according to the character of the adjoining elements. In general we may distinguish:

1a. where elements of the tracheal class are contiguous to one another bilateral bordered pits; their halos are larger than in the libriform elements.

1b. where elements of the libriform class are contiguous to one another pits mostly scarce and:

  2a. bilateral simple pits.

  2b. bilateral bordered pits. The halos smaller than those in the tracheal class.

1c. where elements of the parenchymatic class are contiguous to one another bilateral simple, mostly circular pits.

1d. where elements of the tracheal class are contiguous to those of the libriform class, pits often wanting and if present:

  2a. bilateral simple pits.

  2b. bilateral bordered pits.

  2c. unilateral bordered pits, their halos on the side of the tracheal element.

1e. where elements of the tracheal class are contiguous to those of the parenchymatic class:
  2a. bilateral simple pits.
  2b. unilateral bordered pits, their halos on the side of the tracheal element.
  2c. both bilateral simple and unilateral bordered pits. This is the most common case.
1f. where elements of the libriform class are contiguous to those of the parenchymatic class, pits mostly scarce and:
  2a. bilateral simple pits.
  2b. unilateral bordered pits, their halos on the side of the libriform element.

S. No. 605. (cf. S. No. 584). Secondary phloem. Concerning secondary phloem the following subjects will be dealt with:
1a. special characters of the phloem elements in contrast with xylem elements. See S. No. 606.
1b. classes of elements. See S. No. 607.
1c. idioblasts. See S. No. 612.
1d. conjugated or copulated elements. See S. No. 613.
1e. keratenchyma. See S. No. 614.

S. No. 606. (cf. S. No. 605). The following characters may be mentioned as belonging to the elements of secondary phloem in contrast with those of secondary xylem:
1a. many elements, often the majority of them, are thin-walled and show no lignification.
1b. the cell cavities contain no water.
1c. the cell walls even of older elements are mostly colourless.
1d. bordered pits and spiral bands are wanting.

S. No. 607. (cf. S. No. 605). The following classes of elements may be distinguished:
1a. cribral elements. During their development from cambium fibres they show no longitudinal and at most a very slight transverse growth; moreover they very seldom become septate by the formation of cross walls. They are thinwalled and the walls are provided with sieve-plates. In young basts they contain living protoplasm. See S. No. 608.
1b. bast fibres. During their development from cambium fibres they often show abundant longitudinal sliding but no important transverse growth, moreover they may sometimes become divided into cells by cross walls. They are fibres mostly with a small cavity. Pits in the walls not very abundant, often slit-like and not rarely branched. At a later stage they often contain air. See S. No. 609.
1c. parenchymatic elements. During their development from cambium fibres they mostly show no longitudinal or transverse growth, moreover they are mostly divided into cells by cross walls but nevertheless in most cases the original fibres remain discernible.

They mostly show a large cavity and thin walls but cases are not rare in which they become sclerotic, often with very small cavities. In young bast they contain living protoplasts and often starch, tannin, crystals, etc. See S. No. 610.

S. No. 608. (cf. S. No. 607). Cribral elements are represented only by sieve-tubes. Confer S. No. 580.

S. No. 609. (cf. S. No. 607). Among bast fibres we may distinguish:
1a. ordinary or non septate bast fibres. *Cinchona, Daphne Mezereum,* stem.
1b. septate bast fibres. They are divided into cells by one or more very thin unpitted cross walls; their side walls may be pitted. *Vitis vinifera, Platanus, Aesculus,* stem.
1c. thin-walled bast fibres. They sometimes become thick-walled at a later and even very late stage. *Taxus baccata, Cephalotaxus Fortunii, Thuja,* stem.

S. No. 610. (cf. S. No. 607). Among parenchymatic elements we may distinguish:

1a. bast parenchyma cells. These cells are formed not by initial cells of the cambium, but by segments thrown off by those initial cells, so that the same initial cell can afterwards produce also elements belonging to another class. They arise from the segments in consequence of cross divisions, but the shape of these fibres often remains discernible and thus bast parenchyma fibres are formed; the partition cells have the shape of oblong 4- to 8-sided prisms with longitudinally directed axis. They are mostly thin-walled, but they may develop into sclereids with very thick walls, mostly still showing the shape of bast parenchyma fibres. (*Simaruba excelsa, Sequoia gigantea, Eucalyptus corymbosa*). Pits most abundant in the transverse walls.

2a. substitute bast parenchyma fibres. These elements have mostly the shape of fibres; they are developed from cambial fibres without cross divisions; their length is the same as that of the bast parenchyma fibres of the same plant. They are thin-walled. *Cochlearia Armoracia,* root.
1b. medullary ray cells. These elements arise from cambial initial cells which are themselves divided by transverse walls into cells, so that the same initial cell does not afterwards produce elements belonging to any other class; the shape of fibres usually has been lost. The shape of the cells is that of 4- to 8-sided prisms often with rounded edges. They are mostly thin-walled, but they may develop into sclereids with very thick walls (*Leucodendron argenteum*). Their tangential walls are generally most abundantly pitted. Intercellular spaces occur. See S. No. 611.

S. No. 611. (cf. S. No. 610). Among medullary ray cells we may distinguish:

1a. procumbent or horizontal cells. They often constitute broad pluriseriate layers. Their largest diameter is radially directed. They exhibit narrow intercellular spaces mostly extending in a radial direction. *Bergsmia Sumatrana.*
1b. erect, vertical or upright cells. They mostly constitute uniseriate layers. Their largest diameter is longitudinally directed. *Bergsmia Sumatrana.*

S. No. 612. (cf. S. No. 605). Idioblasts of various kinds are often to be found in secondary phloem e.g. crystal cells (*Punica Granatum*, stem and root), oil cells and mucilage cells (*Cinnamomum Zeylanicum*), enzyme cells (*Cochlearia Armoracia*, root), latex cells (*Exogonium Jalapa*, root). They mostly belong to the parenchymatic class of elements (in *Cochlearia Armoracia* substitute fibres).

Latex vessels often play a conspicuous part in the construction of secondary phloem. *Scorzonera hispanica*, root.

S. No. 613. (cf. S. No. 605). Conjugated or copulated elements. Confer S. No. 602 (may sometimes occur).

S. No. 614. (cf. S. No. 605). Keratenchyma is a term sometimes used for parts of secondary phloem consisting of entirely compressed elements of the cribral class. *Glycyrrhiza glabra*, root.

S. No. 615. Tissues. (cf. S. No. 553). By way of introduction the following subjects will be dealt with:
1a. origin of tissues. See S. No. 616.
1b. relation of formation of tissues and growth. See S. No. 617.
1c. formation of tissues by meristems. See S. No. 618.
1d. formation of tissues and distribution of cell divisions. See S. No. 626.
1e. primary, secondary, tertiary etc. growth and tissues. See S. No. 627.
1f. dilatation growth and dilatation tissues. See S. No. 628.
1g. extension of tissues in the plant-body. See S. No. 629.
1h. storied-, tier-like, stratified and non-stratified arrangement. See S. No. 626.
1i. intercellular spaces in tissues. See S. No. 633.
1j. kinds of tissues constituting the plant-body. See S. No. 636.

S. No. 616. (cf. S. No. 615). Origin of tissues. Tissues may be formed:
1a. by repeated cell divisions, which is the ordinary mode.
1b. by association of originally more or less isolated cells. *Hydrodictyon*, coenobia; hyphal tissues of *Thallophyta* are more or less formed in the same way. Confer S. No. 14.

S. No. 617. (cf. S. No. 615). The formation of tissues by repeated cell divisions is in the large majority of cases preceded and accompanied by growth. It is however not exceptional that growth takes place without formation of tissues, because there are no cell divisions. Thus protoplasmic parts, starch-grains and cell walls may exhibit growth not directly leading to cell divisions and it is clear that unicellular plants, although they may sometimes exhibit considerable growth, like *Vaucheria* or *Caulerpa*, do not form tissues. Even in multicellular plants some special cases occur in which considerable growth is not combined with the formation of new tissues; examples of this kind are afforded by *Palm* stems; active secondary growth of the sheaths of the fibrovasal bundles (*Oreodoxa*) [1]), dilatation growth in the parenchyma between the fibrovasal bundles (*Livistona*) [2]); the cortex of many stems.

On the other hand tissues may be formed without any growth, e.g. the connecting vascular strands between the base of an adventitious root and the fibrovascular strands in the interior of the stem stele in *Palms* and many other Monocotyledons.

S. No. 618. (cf. S. No. 615). Meristematic development in the vegetable kingdom. Concerning the formation of tissues by meristems the following subjects will be dealt with:

1a. meristem, definition of the term. See S. No. 619.
1b. kinds of meristems according to the parts they produce. See S. No. 620.
1c. reciprocal arrangement of full meristems and permanent tissues they produce. See S. No. 621.
1d. reciprocal relations between meristems themselves. See S. No. 622.
1e. special kinds of cambium. See S. No. 623.
1f. structure of meristematic tissues. See S. No. 624.
1g. periclinal and anticlinal cell walls. See S. No. 625.

S. No. 619. (cf. S. No. 557 and 618). Meristem or meristematic tissue. This term designates a tissue of cells exhibiting so low a grade of differentiation, that by further development in various directions they can produce adult cells of all kinds, fit for the performance of all the various functions which may be necessary in plant-life. Such cells are called meristem cells or meristematic cells. The importance of such cells in plant-life has been amply discussed in S. No. 27, dealing with development and thus it is sufficient to mention here only their principal characters. They are small cells, having thin cell walls, small colourless plastids and small vacuoles, but cell-nuclei of the same dimensions as in adult cells. These cells, when active, are in a state of division and consequently may often show nuclear division and recently formed partition-walls. They may enter into a resting or dormant state in which they may remain for a long time, even for many years, without showing cell divisions or recently formed partition-walls, but in favourable circumstances they may return to the active state. Active meristem cells are mostly young cells in so far as the last cell division by which, as daughter cells, they became cell individuals mostly happened a short time ago; but in their resting state, for instance in winterbuds, they may be some months old, in dormant buds of trees even many years.

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[1]) J. C. Schoute. Ueber das Dickenwachstum der Palmen. Ann. d. Buitenzorg, 26, 1912, p. 187.

[2]) Schoute. Ibidem. p. 130.

S. No. 620. (cf. S. No. 618). With respect to the character of the parts produced by meristems we may distinguish:
1a. full meristems. They form complete parts of the external segmentation, which is the subject of organography. All primary tissues (see S. No. 627) belonging to these parts are formed by them. They show cell divisions in various directions. Hence the whole longitudinal growth and the primary growth in thickness of these parts is due to them. Vegetative cones of roots and stems. See S. No. 621.
1b. cambia or cambium layers. They never form complete parts of plants like roots, stems, etc., but only special tissues, mostly permanent and sometimes showing a very complex character. They appear always in the shape of internal layers from one up to a considerable number of cells thick. These layers extend in the great majority of cases parallel to the lateral surface of the part containing them. Their cell divisions predominantly take place in a single direction and the new cell walls extend in the plane of the cambium layers, which therefore throw off tissues either from one or from both surfaces. See S. No. 623. Hence cambium layers mostly do not contribute to the longitudinal growth, but only to the growth in thickness of the parts containing them. They produce secondary tissue (see S. No. 627); in a few cases however primary tissues are produced by them, like in palm-stems where the growth in thickness of the apical meristem chiefly takes place by means of a cambial layer and in roots where the calyptra is formed by the calyptrogen (see S. No. 623), which extends parallel to the apical surface.

S. No. 621. (cf. S. No. 618). With respect to the reciprocal arrangement of full meristems and the permanent tissues produced by them we may distinguish:
1a. apical meristems. They are placed at the top of the parts they produce. They throw off permanent cells either only towards the base (most stems; leaves of *Ferns)*, or they may also form permanent tissue at their apex, thus becoming covered by a cap of permanent tissue (root-cap). They are often called vegetative cones and for most roots and many stems (*Elodea*) this term is very suitable, but it should be kept in mind, that the apical meristems of numerous stems are by no means conical, many showing a flat and even depressed upper surface (*Palms*).
1b. intercalary meristems, basal meristems or basal meristem layers. They are placed at the base of the parts they produce. *Allium Cepa,* leaf; *Gramineae* and *Equisetum,* internodes.

S. No. 622. (cf. S. No. 618). With respect to the reciprocal relations between meristems themselves we may distinguish:
1a. primitive meristem. The whole plant, being in an embryonic stage, consists of meristem. Embryo's of all kinds.
1b. primary meristems. Parts of the primitive meristem still remaining when permanent tissues have already been formed. Many vegetative cones; cambium sheaths producing secondary phloem and xylem in caulomes.
1c. adventitious meristems. This term designates meristems which may appear anywhere, if only living cells are available and which lead to a renewed and additional meristematic growth producing tissues and sometimes external parts or even whole plants. They often arise by renewed divisions of permanent cells in some cases more or less independent of other meristematic tissue. Examples are afforded by many normal cork-cambia or phellogens, by meristems producing tertiary, quaternary, etc. tissues, as in *Ipomoea Purga*, root; *Rheum officinale*, caudex; *Beta vulgaris*, root; by many galls or aecidia.

The formation of adventitious meristems is often caused by the occurrence of wounds in the vicinity of living cells. Thus wound-cork may be formed in many cases; also whole plants from a meristem produced by the epidermal cells of *Begonia*-leaves; and adventitious roots in the pericycle of cuttings [1]).

Very often a so-called callus tissue is formed in the neighbourhood of wounds by the action of meristematic or permanent cells. This tissue consists of colourless thin-walled parenchyma cells and often overgrows the wounds, exhibiting a more or less cauliflower-like appearance. In callus tissue there may arise cambia, but also full meristems producing cormi and roots.

S. No. 623. (cf. S. No. 618). Special kinds of cambium:
1a. with respect to their activity on one or on both surfaces:
2a. monopleuric or one-sided cambia. They produce new tissue only on one side. *Dracaena*, stem, phellogen; phellogen of dicotyledonous plants producing no phelloderm. See S. No. 665.
2b. dipleuric or two-sided cambia. They produce new tissue on both sides. Cambia producing secondary xylem and phloem.
1b. with respect to the tissues produced by them:
2a. phellogen or cork-cambium. Producing secondary cork tissue. See S. No. 663.
2b. calyptrogen. Producing the calyptra of the root. See S. No. 724.
1c. with respect to their arrangement:

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[1]) A curious example of this kind was observed by me many years ago on the stump of a tree of *Populus*, which had been sawed off near the ground. It had been a tree of tolerable dimensions and there had been developed from the cambial sheath between wood and bast a very considerable number of shoots, some centimeters in height exhibiting flattened caulomes, like fasciations.

2a. fascicular cambium. Lying between xylem and phloem in a vascular bundle. See S. No. 715.

2b. interfascicular cambium. Lying in a medullary commissure (see S. No. 715) between two vascular bundles.

S. No. 624. (cf. S. No. 618). In full meristems and young embryo's some differentiations may ensue and in this respect we may distinguish:

1a. procambium strands. They are formed by more or less elongated meristematic cells and indicate the places where in the permanent state strands of vascular tissue will appear. Embryo's of vascular plants.

1b. cells proceeding to the permanent state long before the greater part of the meristem is differentiated. Thus a kind of mature idioblast will appear in the meristematic tissue. Of most common occurrence are:

2a. trichomes. *Aesculus Hippocastanum,* stem and leaves in bud condition.

2b. spiral vessels. Many apical meristems.

2c. crystal cells. Often containing raphides.

2d. oil cells.

2e. oblito-schizogenous glands. *Pimenta officinalis,* embryo.

S. No. 625. (cf. S. No. 618). In meristems exhibiting more or less rounded shapes we may distinguish:

1a. periclinal cell walls. All walls parallel to the outer surface of the meristem.

1b. anticlinal cell walls. All walls meeting the surface and the periclinal walls at right angles.

S. No. 626. (cf. S. No. 615). With respect to the distribution of cell divisions during the development of the tissues we may distinguish:

1a. diffuse[1]) growth. All cells destined to form the tissue divide simultaneously and with exception of certain rhythmic variations take part equally in the formation of the tissue. Meristematic tissue giving rise to the formation of dicotyledonous leaves; adult cells in filaments of *Spirogyra* and in *Ulva*; both cases leading to complete organs or even plant-individuals.

In the formation of cambia diffuse growth may occur in the very first stages and to these cases of partial development the terms polygenous cambium and polygenous permanent tissue have been applied[2]), designating a cambium on whose radial cell rows groups of cells may be observed arising from different adjacent primary cells, so that not all cells of a radius are sister cells. Examples are afforded by *Ricinus communis*, stem, first appearance of interfascicular cambium in adult cells; *Vitis Labrusca, Ruta graveolens, Echium vulgare, Juglans regia* and *Oxybaphus nyctagineus* [1]), stems, first appearance of the whole cambium destined to form secondary xylem and phloem; *Cordyline rubra*, cambium in caulome producing secondary vascular bundle tissue in its first stage.

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[1]) J. C. Schoute. Ueber das Dickenwachstum der Palmen. Ann. d. Buitenzorg, 26, 1912, p. 204 and 207.

[2]) J. C. Schoute in Beyer, Die Vermehrung der radialen Reihen im Cambium. Rec. trav. bot. néerl., 24, 1927, p. 649.

1b. transit celled growth giving rise to transit celled cambia and transit celled permanent tissue. This term designates a special case of polygenous growth in which the cells destined to form the tissue do not divide simultaneously, although for the rest, except for certain rhythmic variations, they take part equally in the formation of the tissue. One or more rows of cells show a certain number of divisions. The thus formed daughter cells all pass into the adult state, so that no cambial cells would remain, if other rows of cells outside the cambium had not assumed cambial properties and succeeded the original mother cells in their function of dividing. In the transit celled permanent tissue formed in this way the arrangement of the cells often displays the offspring of the single primary mother cells. Examples are afforded by several monopleuric cambia, like *Dracaena*, stem, secondary cork tissue and secondary vascular bundle tissue for a long time till replaced by monogenous growth; wound cork.

1c. initial celled growth giving rise to initial celled full meristems or cambia and to initial celled permanent tissues; to initial celled cambia the term monogenous cambia has been applied (Schoute 1927, l.c.). One or more up to numerous cells, destined to form the tissue, show a number of divisions, unlimited in so far as they continue to divide as long as the formation of the tissue lasts. These cells are called initial cells. The cells they throw off are called segments which form the tissue either at once or mostly after a restricted number of cell divisions. With respect to number and distribution of initial cells we may distinguish the following cases:

2a. the meristem contains only one initial cell. The apical meristems (cf. S. No. 621) in many Pteridophytes, e.g. *Equisetum*, and some Algae, e.g. *Sphacelariales*. The single initial cell in apical meristems is called apical cell; it is conspicuous by its form, differing from that of neighbouring cells and often by its greater size. It is not necessarily a true meristematic cell, as may be attested by *Stypocaulon* and *Cladostephus verticillatus*. Yet the majority of examples are afforded by full meristems and in these cases the apical cells may show various shapes among which the principal are:

3a. the upper part of a sphere. *Chara*.

3b. a three-sided pyramid with its base turned towards the surface of the meristem; new walls parallel to the sides of the

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[1]) J. C. Schoute, Ueber Zelltheilungsvorgänge im Cambium, Verhand. Kon. Akad. Amsterdam, 2nd sect. 9, 4, 1902.

pyramid are successively formed in a spiral direction and give rise to the formation of three rows of segments. *Equisetum* and *Musci,* cormi.

3c. a four-sided pyramid with its base turned towards the surface of the meristem; new walls parallel to the sides of the pyramid are successively formed in a spiral direction and give rise to the formation of four rows of segments. *Fucus* and allied genera.

3d. a wedge with its base turned towards the surface of the meristem; new walls parallel to the two sides of the wedge are alternately formed and give rise to the formation of two rows of segments. *Selaginella,* zygomorphous shoots.

2b. the meristem contains one single row consisting of two, three or more, but always a very limited number of initial cells. Vegetative cones of shoots and roots in *Angiospermae,* where the row of initials lies in the axis of the organ, and where the initials are in no respect different from the neighbouring cells; each initial corresponds to a cell layer which exhibits a certain independence in its cell divisions. The group of initials as an assemblage is called vegetative point [1]).

2c. the meristem contains a large number of initial cells, often many thousands, all lying in a single surface. With respect to form and position of the surface we may distinguish the following cases:

3a. the initials lay in a plane, perpendicular to the longitudinal axis of the organ. Basal or intercalary meristems (cf. S. No. 621).

3b. the initials lay in a cylindrical, conical or paraboloid surface parallel to the surface of the organ. Cambia (cf. S. No. 620). In cambia the initial cells may show the following arrangements:

4a. a storied, tier-like [2]) or stratified arrangement. The initial cells lay in shorter or longer transverse rows. This phenomenon is caused by the fact that in such cases the increase in girth [3]) of the cambium takes place by means of divisions of the initial cells; in the youngest cambia the storied arrangement is therefore always lacking.

As a consequence of this arrangement of the initial cells all cambial elements, initial cells and segments, lie more or less in regular transverse planes, in layers each a single cellular element in height, unless the arrangement is disturbed by intracambial sliding growth of the segments. The secondary phloem and xylem, derived from such a cambium, may retain the same storied arrangement (*Herminiera elaphroxylon,* wood); in many cases however the arrangement is obscured by intra- or extracambial sliding growth. See moreover S. No. 673 and 691.

4b. a non-stratified arrangement. The initial cells exhibit an irregular arrangement. This phenomenon is caused by the fact that the increase in girth of the cambium takes place by means of cell division combined with longitudinal growth of the initial cells [1]. *Alstonia* spec, root cambium (radial walls in the initial cells, with longitudinal growth); *Pinus sylvestris*, wood (oblique walls with longitudinal growth).

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[1]) J. C. Schoute, Die Stelär-Theorie, Groningen and Jena 1903, see p. 14.

[2]) F. von Höhnel, Ueber stockwerkartig aufgebaute Holzkörper, Kais. Akad. d. Wis., Wien, I Abt., 89, 1884.

[3]) I. W. Bailey, The cambium and its derivative tissues, IV, The increase in girth of the cambium. Amer. Jour. of Bot. 10, 1923.

As a consequence of this arrangement there are no transverse stories of cellular elements in the cambium nor in the phloem or xylem produced by it; all these are non-stratified. Examples are afforded by the great majority of secondary xylem and phloem tissues and by secondary cork tissues exhibiting a notable increase in girth as in *Fagus sylvatica*.

See moreover M. N. No. 28.

S. No. 627. (cf. S. No. 615). Primary and secondary, respectively tertiary, quaternary, etc. growth and tissues. With respect to the period in which they arise we may distinguish in many higher plants:

1a. primary growth and primary tissues. These terms designate growth and tissues arising in an organ before the longitudinal growth of the organ is ended. Hence this growth is a combination of longitudinal growth and growth in thickness. Primary tissues are generally formed by full meristems, either apical or basal and only in a few cases by cambia: stems of *Palms* and other monocotyledons in their apical meristems (cf. S. No. 620). In consequence of their growth in thickness these tissues may sometimes, though by no means usually, exhibit an arrangement in transverse, often radial rows, a phenomenon otherwise appearing in the majority of secondary tissues for which it is typical. The following examples of radial arrangement in primary tissues may be cited: inner part of cortex in roots, for instance *Brassica nigra*, radicle of embryo, and *Philodendron bipennifolium*, aerial root; other examples to be found in the metaxylem of many vascular bundles. In some cases although the divisions giving rise to primary tissues take place during longitudinal growth, the differentiation of the cells is put back till after this period (metaxylem).

1b. growth and tissues of a higher order. All arising after the longitudinal growth of the organ is ended. Hence this growth is only growth in thickness.

2a. secondary growth and tissues. These terms designate growth and tissues arising from primary tissues. In secondary tissues the arrangement of their cells in transverse, often radial, rows originally is of most common occurrence, although it may be afterwards disturbed. In the great majority of cases they are formed by cambia; but numerous exceptions are to be found in the dilatation tissues, which also afford examples of secondary growth without the formation of secondary tissues. See S. No. 628. Examples of secondary tissues: secondary cork-tissue (see

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[1] J. J. Beyer Die Vermehrung der radialen Reihen im Cambium, Recueil. trav. bot. néerl. 24, 1927, p. 631.

S. No. 661), secondary xylem and phloem (see S. No. 661) and secondary vascular bundle tissue (see S. No. 661).

2b. tertiary, quaternary, etc. growth and tissues. These terms designate growth and tissues arising from secondary, respectively tertiary, etc. tissues. *Ipomoea purga*, roots; *Rheum officinale*, caudex; *Beta vulgaris*, root.

S. No. 628. (cf. S. No. 615). Dilatation growth and dilatation tissue. The first term designates a growth having a more or less passive character, because it is induced as a consequence of the active growth of other tissues belonging to the same member and sometimes in consequence of the fact that neighbouring tissues have not extended in harmony with the growth of the whole member (dilatation growth in the parenchyma surrounding groups of sclereids which form the so-called grits of pears). Dilatation tissues in the majority of cases arise by divisions taking place in mature cells but in dilatated cambia this of course is not the case. Dilatation tissues are formed by dilatation growth.

Although dilatation growth and tissues in general do not play an important part in the development, they are of very common occurrence, both in primary and in secondary tissues. Their distribution throughout the vegetable kingdom deserves closer investigation. The enormous enlargement exhibited by many ovaries, when developing into fruits, is certainly often accompanied by phenomena of this kind, like for example in the fruit-epidermis of *Citrus* [1]) and *Cucurbita*. It further remains to be investigated in how far the more passive longitudinal growth of the cortex in many stems in contrast with the more active growth of the pith leads to consequences of the same kind. Yet the greater number of the best-known examples are to be found among secondary, tertiary, etc. tissues. The principal examples of secondary dilatation growth and tissues are the following:

1a. in the epidermis. See S. No. 702.
1b. the primary cortex of many stems. See S. No. 702 and 703.
1c. the secondary phloem of many stems and roots. See S. No. 699.
1d. the increase in girth taking place in cambia. See S. No. 702.
1e. the inner parenchyma of the stele. See S. No. 702.

The active growth in the examples mentioned sub 1a—1d inducing dilatation growth is the internal growth of the secondary xylem and therefore dilatation growth and dilatation tissues appear in regions lying near to the periphery. They are further most conspicuous in young roots and stems, because in older and thicker parts the same enlargement of radius causes only a relatively slight extension of the peripheral layers, whilst moreover in these older phases the external tissues are mostly dead or even thrown off.

S. No. 629. (cf. S. No. 615). Concerning the size and extension of tissues in the plant-body the following subjects will be dealt with:

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[1]) Botanical Pen-portraits, p. 90.

1a. general survey. See S. No. 630.
1b. layers. See S. No. 631.
1c. sheaths. See S. No. 632.

S. No. 630. (cf. S. No. 629). With respect to the arrangement of cells or groups of cells exhibiting a differentiation different from that in surrounding or adjacent cells, we may distinguish in tissues:
1a. idioblasts. Isolated cellular elements. *Acorus Calamus*, rhizome, oil-cells and tannin-cells; *Camellia japonica*, leaf, mesophyll, sclereids and sclerenchyma fibres.
1b. cell-clusters. Relatively small groups of cells. *Pear*, clusters of sclereids occasioning the so-called grit.
1c. cell-rows. Consisting of a series of cells. Many cases of crystal cells arising from the division of a fibre in secondary phloem and xylem.
1d. bundles. Relatively thin strings of cellular elements. Sclerenchyma fibres in many pericycles; spiral vessels in the veinlets of many leaves.
1e. layers. Plates one or more cellular elements thick. See S. No. 631.

S. No. 631. (cf. S. No. 630). Among layers of cellular elements we may distinguish:
1a. sheaths. They are cylindrical layers enclosing other tissues; they consist either of cells or fibres and may be one up to many elements thick. See S. No. 632.

If a sheath consists of elements differentiated in such a manner that they more or less impede communication between the tissues on either side, it often shows here and there passage cells, not differentiated in the same way. *Dendrobium nobile*, aerial root, exodermis and endodermis, sheaths of sclereids with thin-walled passage cells.
1b. hypoderma. Consisting of sclerotic or collenchymatous elements and lying directly under the epidermis of the part exhibiting it; it is composed either of cells or fibres and may be one or more elements thick. *Radix Sarsaparillae*; many collenchyma layers in stems.
1c. epithelium. Layer consisting of glandular cells and either situated at the surface of the plant (many nectaria) or bordering on the cavity of an internal gland. *Pinus*, leaf, resin ducts, *Foeniculum vulgare*, vittae of young fruit. These layers may be one or a few elements thick, showing no intercellular spaces between them.

It follows from the description given here, that in vegetable histology the term epithelium is used in a much more restricted sense than in animal histology.
1d. palisade tissues. Consisting of cylindrical cells which lie in one plane, and have all the same height. These layers may be one or more cells thick and are always directed parallel to the surface of the part containing them, so that their cylindrical cells stand perpen-

dicular to that surface. Intercellular spaces may be wanting, they are never very large and are always running for the greater part parallel to the long axis of the cylinders. *Punica Granatum*, seed, epidermis.

As special kinds of palisade-tissue we may distinguish:

2a. palisade chlorenchyma. Most dicotyledonous leaves, mesophyll of upper side; *Equisetum*, stem, cortex.

2b. palisade sclerenchyma. *Phaseolus multiflorus*, seed-coat, epidermis.

2c. palisade epithelium. *Prunus Laurocerasus*, leaf, nectaria; *Drosera*, head of tentacle.

1e. metatracheal and metacribal parenchyma bands in secondary xylem (see S. No. 674, 1c, 2a, 3c) and secondary phloem (see S. No. 692, 1b).

1f. absciss layers. Consisting of absciss-cells. Deciduous leaves, twigs and fruits. (cf. S. No. 565).

S. No. 632. (cf. S. No. 631). With respect to the histological differentiation of sheaths we may distinguish as principal kinds:

1a. protective sheath. Consisting of parenchyma cells showing in transverse sections casparian dots fully described in S. No. 562. *Vicia Faba*, primary root of seedling; *Equisetum*, stem [1]).

1b. starch-sheath. Consisting of starch-cells containing often more abundant starch and larger grains than the adjacent tissues on either side. *Ricinus communis*, stem, endodermis; *Hyoscyamus niger*, leaf, endodermis.

1c. protective sheath and starch-sheath combined. *Erythraea centaurium*, stem, endodermis; *Menyanthes trifoliata*, leaf, endodermis.

1d. sclerenchyma-sheath. Consisting of:

2a. sclereids. *Pinus*, leaf, internal glands.

2b. sclerenchyma fibres. Fibrovasal bundles: *Zea Mays*, stem; *Palms*.

1e. crystal-sheath. *Glycyrrhiza glabra*, root, secondary phloem, enclosing the bundles of bast fibres.

1f. sheath of stegmata or covering plates. Fibrovasal bundles of *Palms* and *Ferns* (cf. S. No. 562).

1g. periderm-sheath. Many cases of secondary cork tissue; *Vitis vinifera*, twigs.

1h. cambium-sheath. Consisting of meristematic cells or fibres. (cf. S. No. 557).

1i. root-sheath. See velamen S. No. 725.

S. No. 633. (cf. S. No. 615). Concerning intercellular spaces the following subjects will be dealt with:

1a. schizogenous and lysigenous intercellular spaces. See S. No. 634.

1b. development of schizogenous intercellular spaces. See S. No. 635.

S. No. 634. (cf. S. No. 633). Intercellular spaces are to be found

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[1]) cf. for other examples: v. Tieghem, Journ. d. Bot., 5, 1895, p. 165.

in many tissues. With respect to the mode of their origin we may distinguish:
1a. schizogenous intercellular spaces. Confer for their description S. No. 549. They generally appear as narrow, often triangular ducts between the elements; in many cases they attain larger sizes, forming passages or chambers of considerable dimensions. In the latter two cases a subsequent enlargement may take place by cell-divisions in the tissue surrounding the air-spaces. See S. No. 635.
1b. lysigenous intercellular spaces. Arising by the destruction of cellular elements, unable to keep pace with the growth of the surrounding tissues. Remnants of those elements, stretched and torn are mostly to be found in these spaces. Hollow stems of plants in consequence of destruction of the medulla; many canals in the protoxylem of vascular bundles, e.g. *Zea Mays*, stem.

S. No. 635. (cf. S. No. 633). With respect to the extent of development of schizogenous intercellular spaces we may distinguish:
1a. tissues without intercellular spaces. Epidermis without stomata of many seeds (*Linum usitatissimum*) and leaves (*Nymphaea alba*, upper side); libriform in secondary xylem.
1b. tissues with ordinary narrow intercellular spaces. Cortical and medullary parenchyma of many stems e.g. *Sambucus nigra*.
1c. spongy tissue. Parenchyma exhibiting wide intercellular spaces. The enlargement of these ensues by subsequent growth of the cells between which they were originally formed. By this growth those cells attain more or less irregular often stellate shapes, but the number of cells surrounding the intercellular spaces remains always limited. *Juncus*, stem, medulla.

A special kind of spongy tissue is:

2a. spongy chlorenchyma. *Citrus vulgaris*, leaf mesophyll. See also S. No. 719.
1d. aerenchyma. Parenchyma exhibiting very wide intercellular passages and chambers. The enlargement of these intercellular spaces ensues by subsequent growth of the cells originally in contact with one another, accompanied by reiterated cell divisions by walls which are perpendicular to the intercellular spaces, so that the passages and chambers are surrounded by a much larger number of cells than ordinary intercellular spaces, but the daughter-cells exhibit simple shapes and are of moderate size. Passages and chambers are often separated from one another by layers only a single cell thick. *Nymphaea alba*, petiole, ground tissue; *Acorus Calamus*, rhizome, cortex and ground tissue; *Polytrichum*, theca of sporogonium.
1e. tissues in which the separation of the cells has been carried so far, that they finally form a mass consisting of isolated cell-groups or even single cells. *Symphoricarpus racemosa*, fruit, pulp.

S. No. 636. (cf. S. No. 615). Kinds of tissues. With respect to their differentiation and their importance in the formation of the plant-body we may distinguish:

1a. simple tissues. They consist preponderatingly of a single kind of cellular elements only. They take part in the formation of all pluricellular plants and among lower plants there even occur examples of a whole vegetative body, consisting only of a single simple tissue (*Spirogyra*, *Ulva*). See S. No. 637.
1b. tissues consisting of more than one kind of cellular elements; they exhibit a certain grade of special differentiation and thus by themselves are never able to form a complete plant-body.

2a. compound tissues. Their constituent parts, viz. various kinds of cellular elements and even of simple tissues, form together internal organs which may exhibit a very complex structure: stomatic apparatus, internal glands, some emissaries, xylem and phloem bundles, vascular bundles, fibrovasal bundles, secondary cork tissue, phloem and xylem, secondary vascular bundle tissue. Perusing the above complete list of compound tissues it is clear that combination of these tissues only can not form whole parts of plants, belonging to the external organisation dealt with in Organography, such as roots, leaves etc.; far less a whole plant. See S. No. 638.

2b. tissue systems. They are the highest kind of tissues constituting by their combination complete plant-bodies and parts of their external organisation; they exhibit the most various grades of differentiation, sometimes being combinations of simple and compound tissues rising to the highest grade of complexity. Epidermis, ground-tissue and stele. See S. No. 702.

S. No. 637. (cf. S. No. 636). Simple tissues. In connection with the several kinds of cells, enumerated above (cf. S. No. 554), we may distinguish a corresponding number of different tissues formed by them. It is not necessary to repeat them all here; the attention may be directed only to the following terms:
1a. meristem. Consisting of meristematic cells. (cf. S. No. 557).
1b. permanent, fixed or mature tissues. Consisting of adult cells. (cf. S. No. 557).
1c. parenchyma. Consisting of parenchyma cells. (cf. S. No. 558).

As special kinds of parenchyma we may distinguish:

2a. xylem parenchyma. The parenchymatic part of primary xylem, consisting of elongated cells. See S. No. 649.

2b. cambiform. The parenchymatic part of primary phloem with the exception of companion-cells and consisting of elongated cells. Primary phloem of most dicotyledonous plants. See S. No. 652.
1d. hyphal tissue or plectenchyma. Consisting of hyphae (cf. S. No. 559), and often formed more or less by association of somewhat independent elements and sliding growth (cf. S. No. 522).
1e. pseudoparenchyma. Consisting of pseudoparenchymatic elements. (cf. S. No. 559).
1f. prosenchyma. Consisting of fibres. Their pointed ends mostly interlocking. (cf. S. No. 558).

1g. common parenchyma. Consisting of thin-walled parenchyma cells. (cf. S. No. 561).
1h. collenchyma. Consisting of collenchymatous elements either parenchyma cells or fibres. (cf. S. No. 561).
1i. sclerenchyma. Consisting of sclerenchymatous elements either sclereids or fibres. (cf. S. No. 561).
1j. periderm. Consisting of periderm cells. (cf. S. No. 562).
1k. transfusion tissue. Consisting of parenchyma cells with bordered pits. (cf. S. No. 563).
1l. water tissue or water-storage tissue. Consisting of water-reservoir cells, either living or dead. (cf. S. No. 566).
2a. epithema. Water tissue provided with intercellular spaces and occurring in some emissaries. It is often surrounded by a parenchymatic cuticularized sheath. *Fuchsia globosa*, leaf; *Ficus elastica*, leaf, upper side.
1m. absciss-tissue. Consisting of absciss-cells. (cf. S. No. 565).

S. No. 638. (cf. S. No. 636). Compound tissues. Among compound tissues we may distinguish:
1a. primary compound tissues (cf. S. No. 627). See S. No. 639.
1b. secondary, tertiary, etc. compound tissues (cf. S. No. 627). See S. No. 661.

S. No. 639. (cf. S. No. 638). Among primary compound tissues we may distinguish:
1a. the stomatic apparatus. See S. No. 640—643.
1b. internal glands. See S. No. 644—646.
1c. the more complex kinds of emissaries. See S. No. 647 and 648.
1d. xylem bundles. See S. No. 649—651.
1e. phloem bundles. See S. No. 652—655.
1f. vascular bundles. See S. No. 656—659.
1g. fibrovasal bundles. See S. No. 660.

S. No. 640. (cf. S. No. 639). Stomatic apparatus. Stomata are intercellular passages, perforating the epidermis. They appear in various forms, but those occurring in all the higher plants are all of the same type and even in *Musci frondosi* and *Anthoceroteae* this type also occurs. Only in the other groups of *Hepaticae* another construction appears but this will not be treated here because it has not given rise to special descriptive terms (*Marchantia*).

S. No. 641. (cf. S. No. 639). In the ordinary type of stomatic apparatus we may distinguish:
1a. guard-cells. They are the cells between which the intercellular passage is formed. In the great majority of cases they are two in number, bean-shaped and turned with their hollow sides towards one another, thus forming the air-passage. On the side adjoining this passage each guard-cell may exhibit two ridge-like horizontal protuberances, projecting above and below into the air-

passage, whilst midway between them the wall remains unthickened and bulges out into the passage. The guard-cells contain spurious chloroplasts exhibiting starch-grains, the latter disappearing only in cases of extreme starvation. According to their state of turgescence the guard-cells may be more or less curved and thus the air-passage may be more or less opened or shut. In a few cases there appear to be four guard-cells because two of the so-called subsidiary cells (1d) have taken the shape of guard-cells and have overgrown the two guard-cells proper (*Pinus*, leaf).

1b. the porus. The air-passage between the guard-cells, divided by the projecting ridges and the bulging out middle part of the guard-cells into:

2a. the front-chamber. Below the upper ridges.

2b. the slit. Between the bulging out middle parts of the guard-cells.

2c. the back-chamber. Above the lower ridges.

1c. the respiratory cavity, air cavity. An intercellular space below the stoma and corresponding with the porus.

1d. subsidiary cells. Epidermal cells changed in shape, adjoining the stomatic apparatus and taking part in its formation. They may be wanting (*Iris*, leaf), but are of very common occurrence; their origin is variable, they may be independent epidermis cells added to the guard-cells (*Gramineae*, leaf) or they may be segments thrown off during the development of the stomatic apparatus, from the mother cell from which the guard-cells also are formed (*Sedum roseum*, leaf); in some cases there is a single subsidiary cell surrounding the guard-cells on all sides (*Aneimia fraxinifolia*, leaf).

S. No. 642. (cf. S. No. 639). With respect to their position we may distinguish:

1a. phaneroporous stomata. They are lying in the level of the epidermis or somewhat elevated above it. *Syringa vulgaris*, *Cannabis sativa*, leaf; *Equisetum arvense*, stem.

1b. cryptoporous stomata. The guard-cells lie below the level of the epidermis being more or less over-arched by the subsidiary cells and lying at the bottom of a cavity corresponding with the pore. This cavity is called vestibule. *Juniperus Sabina*, leaf; *Equisetum hiemale*, stem.

S. No. 643. (cf. S. No. 639). Water-pores or water-stomata are a special kind of stomata to be found on some emissaries (see S. No. 647); their guard-cells are larger than those of ordinary stomata on the same part of a plant. The pores are always open and cannot be closed. The guard-cells often die and disappear in an early stage. *Tropaeolum majus*, *Ficus elastica*, leaf.

S. No. 644. (cf. S. No. 639). Internal glands. They are groups of glandular cells which deposit their secretion in internal cavities from which in general it only escapes through wounds. Their shapes are varying from spherical to cylindrical and they are often very long; their products are of the most different kinds.

S. No. 645. (cf. S. No. 639). In internal glands we may distinguish:
1a. the epithelium lining the cavity which contains the secretion.
1b. the cavity containing the substances which are secreted; it is mostly wide.
1c. the secreted substances in the cavity: ethereal oil, resin, gum.
1d. a sheath surrounding the epithelium, sometimes consisting of sclerotic elements (*Pinus*, leaf), and provided with passage cells, in other cases consisting of thin-walled parenchyma and often wanting.
1e. a cover and evacuation slit. This only occurs in cases when the internal glands lie in close vicinity to the epidermis. The cover consists mostly of two tabular epidermal cells with a slit between them, so that there is sometimes a superficial similarity with stomata (see S. No. 646).

S. No. 646. (cf. S. No. 639). With respect to the mode of development we may distinguish:
1a. schizogenous glands. The cavity of the gland appears as an intercellular space between the cells destined to form the epithelium. They are often provided with a sheath. *Pinus*, secondary xylem and leaf; *Hédera Helix*, stem.
2a. vittae. The long cylindrical schizogenous glands in the pericarp of many *Umbelliferae*. They are lined with a relatively thick layer of vittin (cf. S. No. 522) which moreover forms transverse walls, which seem to divide the cavities of the vittae into several cells.
1b. oblito-schizogenous glands. Schizogenous glands of which the secreting cells are obliterated and become suberized; the cells surrounding the gland moreover sometimes become lignified (many *Myrtaceae*). These glands sometimes show a cover with evacuation slit (*Eucalyptus globulus*, leaf; *Pimenta officinalis*, fruit).
1c. schizo-lysigenous glands. The cavity of the gland at first arises as an intercellular space, but soon afterwards the cells surrounding this space are disorganized, fuse together and form a fluid mass filling the cavity, which thus is much enlarged. Many *Rutaceae*; *Citrus*, pericarp; *Dictamnus fraxinella*, leaf; *Ruta graveolens*, leaf, with cover and evacuation slit.

S. No. 647. (cf. S. No. 639). The more complex kinds of emissaries. Emissaries general are places where under certain circumstances fluid water, mostly containing some substances in solution, may be excreted out of the plant. There are several kinds; and some of them, especially the more complex ones, belong to the compound tissues.

In such emissaries we may distinguish:
1a. the end of a bundle of tracheids or vessels with spirally thickened walls.

1b. an epithema in connection with the spiral elements. (cf. S. No. 637).
1c. water-pores. Either isolated (*Rochea*, margin of leaf) or in groups (*Ficus elastica*, leaf, upperside). (cf. S. No. 643).

S. No. 648. (cf. S. No. 639). Apical openings is a term used for emissaries like those above, but wanting epithema, whilst their water-pores are more or less obliterated (many aquatic plants).

S. No. 649. (cf. S. No. 639). Xylem bundles. They are chiefly composed of tracheal elements and these are never wanting. They often branch and always anastomose with one another throughout the whole plant. They consist of:
1a. vessels: annular, spiral, reticulate, pitted or scalariform vessels.
1b. tracheids: annular, spiral, reticulate, pitted or scalariform tracheids.
1c. xylem parenchyma. Consisting of living cells.

S. No. 650. (cf. S. No. 639). In well developed xylem bundles, such as occur in most roots, stems and leaves, we may distinguish:
1a. protoxylem. That part of the xylem earliest developed from the meristematic procambium strand which gives rise to the bundle, and quite differentiated during longitudinal growth. The tracheal elements are thinner than those of the metaxylem. Sclerenchymatous elements are wanting; it contains chiefly annular and spiral vessels or tracheids. The first developed of these are called primitive or primordial elements. In consequence of the strong longitudinal growth in which it takes part in leaves and stems the elements of protoxylem are often obliterated, and there may even appear a lysigenous intercellular space in their stead. *Zea Mays*, stem.
1b. metaxylem. That part of the primary xylem arising by cell-divisions which take place during longitudinal growth, whilst the elements receive their full differentiation immediately after the lapse of this period. It sometimes exhibits an arrangement of the elements in transverse rows, in this respect resembling secondary tissue. It contains reticulate and pitted vessels or vessel tracheids and also thick-walled fibres.

S. No. 651. (cf. S. No. 639). Xylem bundles are very variable in the degree of their development. They may often lack parenchyma and be reduced to bundles of vessels tracheids, for instance in roots, stems of *Ferns* (*Polypodium*, scalariform tracheids) or smallest veinlets of dicotyledonous leaves (spiral vessels or tracheids).

S. No. 652. (cf. S. No. 639). Phloem bundles. They are chiefly composed of cribral elements; they branch and anastomose in the same way as the xylem bundles. They consist of:
1a. sieve-tubes with or without companion cells.

1b. living thin-walled parenchyma cells which are called cambiform cells. (cf. S. No. 637).

S. No. 653. (cf. S. No. 639). With respect to the occurrence of the various elements mentioned in S. No. 652 we may distinguish the following cases:
1a. There are sieve-tubes and companion cells solely. *Monocotyledons* and *Ranunculaceae*, stem.
1b. There are sieve-tubes and cambiform cells solely. *Pteridophyta* and *Gymnospermae*, stems.
1c. There are sieve-tubes, companion cells and cambiform cells. *Dicotyledons* with the exception of *Ranunculaceae*, stems.

S. No. 654. (cf. S. No. 639). Phloem bundles are variable in the grade of their development. They may occur in a more or less reduced state. Veinlets of dicotyledonous leaves.

S. No. 655. (cf. S. No. 639). In well developed phloem bundless such as occur in most roots, stems and leaves we may distinguish:
1a. protophloem. That part of the phloem earliest developed from the meristematic procambium strand which gives rise to the bundle and quite differentiated during longitudinal growth. The first developed elements are called primitive or primordial elements. In consequence of the strong longitudinal growth in which it takes part in stems and leaves the elements of protophloem are often obliterated and at the same time compressed; it may be called keratenchyma (cf. S. No. 614). *Zea Mays*, stem; *Ranunculus repens*, runner.
1b. metaphloem. That part of the primary phloem arising by cell-division which takes place during longitudinal growth whilst the elements receive their full differentiation immediately after the lapse of this period.

S. No. 656. (cf. S. No. 639). Vascular bundles. This term is used in a comprehensive sense for designating combinations of one or more phloem bundles and one or more xylem bundles, either closely adjoining one another or separated by an adult parenchyma or a cambium. In more complex cases medullary commissures (see S. No. 706) take also part in the formation of the vascular bundle. In the most simple cases on the other hand the term is used even for a single xylem bundle (smallest veinlets of dicotyledonous leaves).

S. No. 657. (cf. S. No. 639). With respect to the occurrence of medullary commissures in the vascular bundles we may distinguish:
1a. simple vascular bundles. Medullary commissures wanting. *Cucurbita Pepo, Zea Mays*, stem.
1b. compound vascular bundles. Consisting of two or more simple vascular bundles separated from one another by medullary commissures. *Linum usitatissimum*, stem; midrib of many dicotyledonous leaves.

S. No. 658. (cf. S. No. 639). With respect to the occurrence of a cambium between the phloem and xylem bundles we may distinguish among simple bundles:
1a. closed vascular bundles. Cambium wanting. *Zea Mays*, stem.
1b. open vascular bundles. Provided with cambium. *Cucurbita Pepo*, stem.

S. No. 659. (cf. S. No. 639). With respect to number and reciprocal arrangement of the phloem and xylem bundles in a simple vascular bundle we may distinguish [1]:
1a. a single phloem and xylem bundle.
  2a. collateral vascular bundles. Phloem and xylem running parallel and side by side. *Zea Mays*, stem.
  2b. concentric vascular bundles. Phloem and xylem, one surrounding the other.
    3a. amphivasal vascular bundles. Xylem surrounding the phloem. *Acorus Calamus*, rhizome; *Dracaena*, stem, secondary vascular bundles.
    3b. amphicribral vascular bundles. Phloem surrounding the xylem. *Gunnera*, *Primula*, stem; *Aspidium Filix mas*, rhizome.
1b. a single xylem bundle and two phloem bundles.
  2a. bicollateral vascular bundles. Xylem bundle in the middle, phloem bundles on two sides opposite each other. *Cucurbita Pepo*, stem.

S. No. 660. (cf. S. No. 639). Fibrovasal bundle. This is a vascular bundle surrounded by a complete or partial sheath consisting of sclerenchyma fibres. *Zea Mays*, stem; *Ranunculus repens*, runner; *Carbenia benedicta* [2], and *Conium maculatum* [3], stem.

S. No. 661. (cf. S. No. 638). Among secondary compound tissues we may distinguish:
1a. secondary cork tissue. See S. No. 662—666.
1b. secondary xylem and phloem. See S. No. 669—671 and 688.
1c. secondary vascular bundle tissue. See S. No. 700 and 701.

S. No. 662. (cf. S. No. 661). Secondary cork tissue. Secondary cork tissues are produced:

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[1] The term radial vascular bundle is not included here. It was introduced by de Bary (Vergl. Anat. 1877. p. 361, or Comparative Anat. 1884, p. 348) and was used by him for the whole stele, only with the exception of the pericycle, when the xylem bundles in roots extend in thickness towards the centre and fuse together there (*Vicia Faba*, root). Though this term agrees with the letter of the description of vascular bundle as given in S. No. 656, its use is inconsistent with the stelar conception and it ought therefore to be considered as obsolete. The term is only mentioned here, because the authority of de Bary has procured it a general use.

[2] Botanical Pen-portraits, p. 294.

[3] Ibidem, p. 313.

1a. in the epidermis. Many trees, e.g. *Sorbus aucuparia.*
1b. in the ground tissue. Often in the cell layers immediately below the epidermis e.g. *Tilia* but also often in deeper layers and even in the endodermis (*Coffea arabica*, stem).
1c. in the stele, and here especially in the pericycle (many roots, e.g. *Glycyrrhiza glabra* and in secondary phloem (rhytidoma see S. No. 698).
1d. wound cork. This may be produced in all tissue systems; it appears mostly in permanent living cells lying in the vicinity of the surface of the wound. *Solanum tuberosum*, wood parenchyma and bast parenchyma of tubers cut into pieces.

In contrast with secondary xylem and phloem the growth of secondary cork is in most cases a very limited one and no meristematic cells remain; thus relatively thin cork layers are formed, but on the other hand the formation of cork tissue may be often repeated (rhytidoma).

S. No. 663. (cf. S. No. 661). In a complete secondary cork tissue arising from a dipleuric cambium we may distinguish:
1a. phellem. The tissue formed on the outside of the cambium; mostly the principal part of secondary cork tissue, periderm generally being its chief constituent.
1b. phellogen or cork cambium. Mostly consisting of a very few layers of cells.
1c. phelloderm. The tissue formed on the inside of the cambium, thin-walled common parenchyma generally being its chief constituent.

S. No. 664. (cf. S. No. 661). Among secondary cork tissue we may distinguish with respect to the occurrence of intercellular spaces:
1a. cork tissue proper. Intercellular spaces are wanting. It generally forms only thin layers, extending over relatively large areas. See S. No. 665.
1b. lenticels. They exhibit intercellular spaces, abundant and often very large and they extend only over small areas. See S. No. 667 and 668.

S. No. 665. (cf. S. No. 664). Secondary cork tissue proper. The following special characters may be mentioned here:
1a. the phellem. Though in most cases wholly or chiefly consisting of periderm, it may nevertheless contain:
2a. sclereids. Sometimes in layers alternating with periderm layers. *Cinnamonum Cassïa*, branches.
2b. phelloid. Thin-walled non-suberized parenchyma.
2c. aerenchyma. *Lycopus europaeus*, stem if more or less growing in water.

In the relatively exceptional cases when phellem layers become very thick there may be formed growth rings, appearing like those in secondary xylem and phloem, in connection with atmospheric influences during different seasons. Thick early layers are formed consisting of thin-walled periderm cells and thinner late layers more thick-walled. *Quercus suber, Ulmus campestris var. suberosa, Passiflora vespertilio*, stem.

1b. the phelloderm. It is often wanting viz. in cases of secondary cork tissues formed by monopleuric cambia (cf. S. No. 623) e.g. *Acer campestre*, twigs; all cases of transitory celled cork like *Dracaena*, stem. When present it mostly has a tendency to be only slightly developed. Consisting of thin-walled parenchyma it may contain idioblasts of various kinds.

S. No. 666. (cf. S. No. 661). With respect to the mode of growth we may distinguish:

1a. transit celled secondary cork tissue. Formed by a transit celled cambium (cf. S. No. 626). *Zingiber officinale*, rhizome; *Geniostoma* and *Coffea arabica*, stem; *Quillaja saponaria*, rhytidoma.

1b. initial-celled secondary cork tissue. Formed by an initial-celled cambium. (cf. S. No. 626). *Syringa vulgaris*.

See moreover M. N. No. 28.

S. No. 667. (cf. S. No. 664). Lenticels. Lenticels may be formed:

1a. simultaneously with the layer of secondary cork tissue proper of which they form a part. In this case phellem, phellogen and phelloderm of the lenticel join at their margins the same tissues of the surrounding layer of secondary cork tissue proper. *Sambucus nigra, Fraxinus excelsior*, twig.

1b. in no direct connection with secondary cork tissue proper.

  2a. lenticels appear first and their formation is followed by that of a layer of cork tissue proper. *Cornus stolonifera*, twigs.

  2b. lenticels in rhytidoma piercing the parts of secondary phloem between the cork-layers.

  2c. lenticels on petioles of leaves, without the formation of surrounding secondary cork tissue proper. *Aesculus Hippocastanum, Aralia.*

S. No. 668. (cf. S. No. 664). The following special characters may be mentioned here:

1a. the phellem may consist of:

  2a. periderm only, the cells have often a tendency to separate from one another. *Fraxinus excelsior, Sambucus nigra.*

  2b. alternating layers of:

    3a. complementary tissue. A mass of partly or wholly isolated cells, the walls of which are often imperfectly or not at all suberized.

    3b. closing membranes or intermediate bands. They consist of periderm cells exhibiting intercellular spaces. *Betula alba*, twigs.

S. No. 669. (cf. S. No. 661). Secondary xylem and phloem. Introduction. We find back here the parallelism mentioned already, when the special cellular elements appearing in secondary xylem and phloem were dealt with (cf. S. No. 584). In the tissues it is signalized by the following facts:

1a. The three classes of elements which occur in both secondary tissues and which are respectively characterized by vasal elements, thick-walled fibres and parenchyma cells (cf. S. No. 586), in the mode of their taking part in the construction of secondary xylem and phloem show a distinct analogy. Moreover we find in both cases now and then a storied or tier-like arrangement (cf. S. No. 626) of the elements, whilst the construction of medullary rays shows far-reaching similarities. See S. No. 673, 674, 691 and 692.
1b. growth rings, at the same time often being annual rings or year rings, may be found in both secondary tissues in consequence of a certain periodicity in the shapes of the elements, due to different periods in the climatological factors. These rings are of most common occurrence in wood, but in secondary phloem they are very exceptional. See S. No. 683 and 697.
1c. In both secondary xylem and phloem there is often a difference between the younger and older parts, so that the inner part of the xylem is changed into heart wood or duramen (see S. No. 686) and the outer part of the secondary phloem into bark or rhytidoma (see S. No. 698). Both these older layers in such cases are composed of dead elements, which often show more or less important differences from their original state.

S. No. 670. (cf. S. No. 661). Secondary xylem and phloem are produced only in the stelar tissue system and are wholly wanting in epidermis and ground tissue.

S. No. 671. (cf. S. No. 661). Secondary xylem. Here the following subjects will be dealt with:
1a. disturbance of radial arrangement. See S. No. 672.
1b. storied or tier-like arrangement of the elements. See S. No. 673.
1c. part taken by the various elements in the construction. See S. No. 674.
1d. medullary rays. See S. No. 675.
1e. phloem bundles in xylem. See S. No. 681.
1f. medullary spots or pith flecks. See S. No. 682.
1g. growth rings. See S. No. 683.
1h. alburnum and duramen. See S. No. 687.

S. No. 672. (cf. S. No. 671). The radial arrangement of the elements in secondary xylem is generally very conspicuous. It is only disturbed by a disproportionate growth in thickness of some elements, especially vessels, or by strong subsequent longitudinal sliding growth (cf. S. No. 522), especially occurring in fibres. Hence it may be said in general that tracheal elements often show a radial arrangement, that libriform fibres often have lost it and that it is to be found almost without exception in the class of parenchymatic elements.

S. No. 673. (cf. S. No. 671). Secondary xylem exhibiting a storied, tier-like or stratified arrangement of the constituent elements is to be found in some families. This phenomenon is best observed in a tangential section and may often be distinguished with the naked eye as a fine transverse undulation or very thin transverse lines. All xylem elements may take part in the formation of the stories or only a part of them, in consequence of a subsequent longitudinal growth of others. In most cases the stories are anchored together by means of the libriform fibres. These elements exhibit a strong sliding growth (cf. S. No. 522) by which their original length may be multiplied several times; they then show often a thick middle part having the length of the original cambium fibre and two long and much thinner ends which have grown between the elements of the adjoining stories above and beneath. Thus an effective reciprocal anchorage of the several stories takes place. Many examples are afforded in Janssonius, Mikrographie des Holzes, of which the reader may consult the index under the head Etagenbau or Stockwerkartiger Aufbau; *Cochlearia Armoracia* ¹) shows the same phenomenon in its root, without reciprocal mooring of the elements.

See moreover M. N. No. 29.

S. No. 674. (cf. S. No. 671). The part taken by the several kinds of elements in the construction of secondary xylem is in general the following:

1a. elements of the tracheal class.
  2a. vessels.
    3a. they are wanting. *Gymnospermae.*
    3b. they form the ground mass of the xylem; a case very seldom occurring.
    3c. the isolated vessels or groups of vessels are scattered in various ways through the ground mass.
      4a. they are distributed uniformly. *Nyssa multiflora.*
      4b. they are arranged in interrupted radial rows. *Quercus rubra.*
      4c. they are arranged in interrupted tangential zones. *Populus grandidentata.*
      4d. they are more numerous in the early wood of the growth rings (see S. No. 685) *Ailanthus glandulosa, Rhus typhina.*
      4e. they are more numerous in the middle layer of the growth rings.
  2b. tracheids.
    3a. they constitute the ground mass of the xylem and are in this case always tracheid fibres. *Gymnospermae*; *Altingia excelsa* ²).
    3b. arranged in groups they surround the vessels, in this case they are always vessel tracheids. *Calophyllum Inophyllum* ³).
    3c. they are more numerous in the late wood of the growth rings or they may even be confined to it (tracheid fibres). *Ribes rubrum* and *nigrum.*

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¹) Botanical Pen-portraits, p. 362.
²) Moll and Janssonius, Mikrographie des Holzes Bd. III. p. 317.
³) ibid. Bd. I. p. 273 and p. 274.

1b. elements of the libriform class.
  2a. non-septate libriform fibres.
    3a. they form the ground mass of the xylem. *Ulmus campestris.*
    3b. they are scattered in groups. *Quercus sessilis.*
    3c. they are more numerous in the middle layer of the growth rings, or even confined to it.
  2b. septate libriform fibres. They are of relatively rare occurrence and in those cases:
    3a. they form the groundmass of the xylem. Many *Bixineae* and *Meliaceae* [1]).
    3b. they are scattered between the non-septate libriform. Many *Albizzia* and *Pithecolobium species* [2]).
1c. elements of the parenchymatic class.
  2a. wood parenchyma.
    3a. it is wanting. *Gymnospermae.*
    3b. it forms the ground mass of the xylem. *Daucus Carota* and *Beta vulgaris*, root; *Solanum tuberosum*, tuber; *Eriodendron anfractuosum, Otophora alata.*
    3c. it is arranged in tangential layers, called metatracheal bands or laminar wood parenchyma; these layers are very common in tropical woods. *Chisocheton sandoricocarpus* [3]), *Swietenia Mahagoni.*
    3d. it is arranged in groups round the vessels, and is called paratracheal or circumvasal wood parenchyma. *Meliosma ferruginea* [4]).
    3c. it is scattered between the fibres. *Eurya acuminata* [5]).
    3f. it is more abundant in the late wood of the growth rings (see S. No. 684) or even limited to it. *Liriodendron tulipiferum.*
  2b. substitute fibres.
    3a. they replace all wood parenchyma and may even form the ground mass of the xylem. *Cochlearia Armoracia*, root [6]).
    3b. they are scattered through the wood parenchyma and take the place of some wood parenchyma fibres. *Pterocarpus indicus* [7]) and many *Leguminosae.*
      4a. they are to be found in all parts of the wood parenchyma.
      4b. they occur only in the late wood of the growth rings (see S. No. 685).
  2c. parenchyma of secondary medullary rays. Radial bands, very different in height and of relatively slight breath.

S. No. 675. (cf. S. No. 671). Concerning medullary rays the following subjects will be dealt with:

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[1]) ibid. Bd. I. p. 197 and II. p. 110.
[2]) ibid. Bd. III p. 185 and 197.
[3]) ibid. Bd. II. p. 161.
[4]) ibid. Bd. II. p. 429.
[5]) ibid. Bd. I. p. 303.
[6]) Pen-portraits, p. 362.
[7]) Mikrographie des Holzes. Bd. III. p. 68.

1a. definition of the term. See S. No. 676.
1b. extension in a tangential direction. See S. No. 677.
1c. various differentiations. See S. No. 678.
1d. various ages. See S. No. 679.
1e. enveloping cells. See S. No. 680.

S. No. 676. (cf. S. No. 675). Medullary rays. This term designates parenchymatic bands, extending with their length in a radial and with their breadth in a longitudinal direction. See moreover M. N. No. 30.

S. No. 677. (cf. S. No. 675). Among medullary rays, with respect to the number of cells exhibited in a tangential direction, we may distinguish:
1a. uniseriate medullary rays. Only a single cell in breadth.
1b. bi-, tri-, up to multiseriate medullary rays. They consist in a tangential direction of two, three up to many cells; in those cases however they are mostly tapering upwards and downwards and are uniseriate at their upper and lower margin. (cf. S. No. 596).

S. No. 678. (cf. S. No. 675). With respect to their special differentiation we may distinguish:
1a. simple medullary rays, mostly called medullary rays without any qualification. They are not composed of different parts which are placed vertically alternating with one another.
1b. compound medullary rays. They are composed of parts or stories arranged one above the other, different in structure and alternating with one another. One kind of story is always formed of upright cells and in the great majority of cases is uniseriate being called uniseriate or narrow story and generally forming the uppermost and undermost stories. The other kind is formed for the greater part or wholly of procumbent cells and generally is pluriseriate being called pluriseriate or broad story and mostly not forming the uppermost or undermost story of the medullary ray.

S. No. 679. (cf. S. No. 675). With respect to their age we may distinguish:
1a. large medullary rays. They reach from pith to cambium; they are very high and often broad; their interior prolongation is formed by the inner part of a medullary commissure; they are interfascicular (see S. No. 715).
1b. smaller medullary rays. They do not reach the pith; they are usually not high and often narrow; they may be either fascicular (see S. No. 715) or in a later stage of the wood also interfascicular.

These two kinds of medullary rays are not to be discerned if not by their dimensions in older pieces of wood containing no pith, but in the vicinity of the pith the large medullary rays are easily distinguished (*Fagus sylvatica*) [1]).

S. No. 680. (cf. S. No. 675). In pluriseriate medullary rays or pluriseriate parts of them the cells of the outermost lateral layers are often upright, and in this case they are called enveloping cells.

S. No. 681. (cf. S. No. 671). In some cases phloem bundles are to be found in secondary xylem. *Strychnos Nux vomica*, stem; *Memecylon paniculatum*, stem [2]).

S. No. 682. (cf. S. No. 671). Medullary spots or pith flecks sometimes occur in wood. They are passages filled up with parenchyma. The parenchyma cells show an irregular arrangement, they are polyhedral, with somewhat thickened pitted walls and various contents, in dry wood often coloured brown. These passages occur in many woods and mostly in the lower part of the trunks; they mostly run in a longitudinal direction; they are flat in a radial direction and they owe their origin to larvae which live in the cambial layer. The passages due to these larvae become soon filled up with parenchyma.

S. No. 683. (cf. S. No. 671). Concerning growth rings the following subjects will be dealt with:
1a. their origin and appearance. See S. No. 684.
1b. layers constituting them. See S. No. 685.
1c. periodicity of the elements. See S. No. 686.

S. No. 684. (cf. S. No. 683). Growth rings, annual rings, year rings. They arise in most woods and are the consequence of a periodicity in the formation of the xylem elements in such a manner that in different seasons the elements formed by the cambium are different in number, in transverse dimensions, sometimes also in thickness of their walls. Especially in woods composed of relatively thin-walled elements the growth rings are most distinct. For the rest the thickness of a growth ring formed within a certain period in one and the same plant individual may be very different, according to its formation either in a trunk or a root or a branch of both, or on one and the same axis at different heights and different sides; the thickness of growth rings exhibits moreover a period in connection with the age of the plant.

In woods of the temperate and cold regions the formation of growth rings is allied to the alternation of summer and winter, so that they correspond with yearly periods; hence the terms annual rings and year rings. In tropical woods growth rings may in a few cases be wanting, but though often less distinct they generally occur. In many of these cases they may correspond with yearly periods, mostly however this is uncertain and in a few cases it probably is not so.

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[1]) K. Zijlstra, Die Gestalt der Markstrahlen im sekundären Holze, Recueil trav. bot. néerl. 5, 1908, p. 17.

[2]) Mikrographie des Holzes, III, p. 559.

S. No. 685. (cf. S. No. 683). In growth rings we may distinguish:
1a. the early wood, spring wood. This is formed at the beginning of the period and is turned towards the axis. The transverse dimensions of the elements especially in a radial direction are larger than in the late wood.
1b. the middle layer. This is formed during the middle part of a period.
1c. the late wood, autumn wood. This is formed at the end of a period and is turned towards the periphery. The transverse dimensions of the elements, especially in a radial direction, are smaller than in the early wood.

S. No. 686. (cf. S. No. 683). The periodicity of the elements in the growth ring may appear in various ways:
1a. The periods of the several characters within each growth ring exhibit only an increase or a decrease, so that minimum and maximum coincide with the boundaries of the growth rings. In this case the boundaries of the growth rings may be abrupt. Woods of the temperate regions generally show this periodicity.
1b. The periods of the several characters within each growth ring exhibit both an increase and a decrease, so that minimum and maximum do not coincide with the boundaries, but one of them occupies a middle position somewhat more towards the early wood. The boundaries between the growth rings are in this case generally somewhat less abrupt. In tropical woods this periodicity often occurs.

S. No. 687. (cf. S. No. 671). In many but not in all woods we may distinguish:
1a. alburnum, splint wood, sap wood. It is the younger part of the wood, containing more water, being lighter and less compact; it contains living elements; its cell walls are mostly colourless or but slightly coloured.
1b. duramen, heart wood. The older part of the wood, formed from the sap wood after a lapse of about 5 to 40 years and mostly separated from it by an abrupt boundary; it contains less water than the sap wood, is heavier, more compact and better adapted to technical purposes; it is quite dead and contains no starch but often thyloses; its cell walls are often coloured intensely and in various ways, in consequence of infiltration with organic substances; its elements often contain in their cavities resinous and other substances, often lining the walls.

Examples of woods without duramen are furnished by *Buxus sempervirens* and *Acer Pseudoplatanus*; those of woods exhibiting duramen *Diospyros Ebenum*, *Pterocarpus Santalinus*, *Haematoxylon Campechianum*.

S. No. 688. Secondary phloem. (cf. S. No. 661). Here the following subjects will be dealt with:
1a. disturbance of radial arrangement. See S. No. 689.
1b. secondary phloem thinner than secondary xylem. See S. No. 690.
1c. storied or tier-like arrangement of the elements. See S. No. 691.
1d. part taken by the various elements in the construction. See S. No. 692.
1e. medullary rays. See S. No. 693.
1f. growth rings. See S. No. 697.
1g. rhytidoma. See S. No. 698.
1h. dilatation tissue in secondary phloem. See S. No. 699.

S. No. 689. (cf. S. No. 688). The original radial arrangement of the elements in secondary phloem is generally only conspicuous in the younger parts of the bast and often only in the vicinity of the cambium. It is not so much disturbed by disproportionate growth of some elements but it is often entirely lost in the outer parts of the bast by dilatation.

S. No. 690. (cf. S. No. 688). Secondary phloem as a rule is much thinner than secondary xylem in the same part of a plant. This is due to the following causes:
1a. On the outside of the cambium a smaller number of cell layers is thrown off than on its inside towards the secondary xylem.
1b. A compression of phloem elements often takes place, which does not occur in xylem.
1c. The outer parts of secondary phloem are often removed after having been transformed into rhytidoma.

S. No. 691. (cf. S. No. 688). Secondary phloem exhibiting a storied, tier-like or stratified arrangement is to be found in the plants that show the same phenomenon in secondary xylem. It is occasioned by the same causes but has been less accurately investigated. Confer S. No. 673. *Simaruba officinalis* and *Cytisus Laburnum*, stem; *Cochlearia Armoracia*, root [1]).

See moreover M. N. No. 29.

S. No. 692. (cf. S. No. 688). The part taken by the several kinds of elements in the construction of secondary phloem is often not so clearly pointed out as in secondary xylem. The following facts may be mentioned:
1a. There is mostly no ground mass formed by a single kind of element.

An exception to this rule is formed by fleshy roots and stems in which the ground mass may be formed by elements of the parenchymatic class viz.:

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1) Botanical Pen-portraits p. 360.

2a. bast parenchyma. *Daucus Carota* and *Beta vulgaris*, root; *Solanum tuberosum*, tuber.

2b. substitute bast parenchyma fibres. *Cochlearia Armoracia*, root.

1b. There is a strong tendency to form in regular succession tangential layers consisting of various kinds of elements. Most *Gymnoperms*, e.g. *Juniperus communis*; many *Dicotyledons*, e.g. *Tilia platyphyllos, Punica Granatum.*

These layers often bear the character of metacribral bands and may be designated as such. *Daphne Mezereum*, stem [1]). *Hamamelis virginiana*, stem [1]); *Rhamnus purshiana*, stem [1]).

S. No. 693. (cf. S. No. 688). Concerning medullary rays the following subjects will be dealt with:

1a. uniseriate, biseriate, etc. See S. No. 694.

1b. simple and compound. See S. No. 695.

1c. large and smaller. See S. No. 696.

S. No. 694. (cf. S. No. 693). Among medullary rays, with respect to the number of cells they exhibit in a tangential direction, we may distinguish:

1a. uniseriate medullary rays. Only a single cell in breadth.

1b. bi-, tri-, up to multiseriate medullary rays. They consist in a tangential direction of two, three up to many cells; in those cases however they are mostly tapering upwards and downwards and are uniseriate at their upper and lower margin. (cf. S. No. 595).

S. No. 695. (cf. S. No. 693). Simple and compound medullary rays may be found in the same plants which exhibit these kinds of medullary rays in secondary xylem. (cf. S. No. 678). As an example of compound medullary rays we may mention *Bergsmia* (*Hydnocarpus*) *Sumatrana.*

S. No. 696. (cf. S. No. 693). With respect to their age we may distinguish:

1a. large medullary rays. They reach from pericycle to cambium; they are very high and often broad; their exterior prolongation is formed by the outer part of a medullary commissure and they are interfascicular (see S. No. 715).

1b. smaller secondary medullary rays. They do not reach the pericambium; they are usually not high and often narrow; they may be either fascicular (see S. No. 715) or in a later stage of the bast also interfascicular.

These two kinds of medullary rays are not to be discerned if not by their dimensions in older pieces of bast in which the formation of rhytidoma has taken place and of which the outer portion has been thrown off. In young branches the large medullary rays are easily to be distinguished (*Tilia platyphyllos*).

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[1]) Botanical Pen-portraits, p. 101, 104, 118.

S. No. 697. (cf. S. No. 688). Growth rings, annual rings, year rings (cf. S. No. 684) are mostly absent in secondary phloem but in a few instances they may be very conspicuous (*Glycine chinensis*, stem).

S. No. 698. (cf. S. No. 688). Rhytidoma or bark is formed in the secondary phloem of many plants. In these cases layers of secondary cork tissue appear in the outer parts of the secondary phloem, cutting them off from intercourse with the younger portions and causing them to die. Such cork layers are repeatedly formed and thus thick layers of rhytidoma may ensue, consisting of alternating layers of dead phloem and secondary cork. In course of time cracks are formed and hence the furrowed appearance of many tree-trunks arises; moreover some cork layers may be torn and thus outer parts of rhytidoma may be thrown off.

With respect to the shape of the cork layers we may distinguish:

1a. scaly rhytidoma, scaly bark. The layers of secondary cork tissue form arches turned with their hollow side outward and covering only smaller or larger areas of the circumference of the secondary phloem. They have oblong, more or less rounded shapes and are to be found in various sizes e.g. small in *Quercus sessilis*, larger in *Pinus sylvestris* and very large in *Platanus*. The first cork layers may be formed in the primary cortex and reach with their margins to the outer surface; the margins of those formed afterwards join other previously formed cork layers. The parts thrown off may be called scales.

1b. annular or ringed rhytidoma or bark. The layers of secondary cork tissue have the shape of complete concentric circular cylinders extending a large way in a longitudinal direction. The parts thrown off split and have the shape of more or less irregular, longitudinal strips. *Vitis Vinifera* and *Clematis*, stem.

S. No. 699. (cf. S. No. 688). Dilatation tissue in secondary phloem. Dilatation tissue always belonging to the parenchymatic class often occurs in secondary phloem and, as has been set forth in S. No. 628, it chiefly appears in relatively thin stems and roots during the early stages in the formation of secondary phloem. It may be considered as of tertiary origin and its formation may take place in one of the following ways 1):

1a. by cell-divisions in bast parenchyma and secondary medullary rays. *Punica Granatum*, root-bark.

1b. by cell-divisions in bast parenchyma only. *Rhamnus Purshiana*, bark.

1c. by cell-divisions of the secondary medullary rays only. In these

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1) H.H. Janssonius, De tangentiale groei van eenige pharmaceutische basten, Thesis Groningen, 1918.

cases the medullary rays mostly take the shape of very distinct wedges with their bases turned outward. *Tilia cordata*; *Cusparia febrifuga*, stem-bark.
1d. by cell-divisions in certain parts of the bast parenchyma leading to the formation of wedges with their bases turned outward. *Viburnum prunifolium*; *Punica granatum*, stem-bark.

S. No. 700. (cf. S. No. 661). Secondary vascular bundle tissue may be produced in the ground tissue and here both in the primary cortex proper and in the endodermis; further in the pericycle.

S. No. 701. (cf. S. No. 661). The cambium by which this tissue is produced may give rise:
1a. on its outside towards the periphery to a more or less developed parenchyma.
1b. on its inside towards the centre it forms:
  2a. a strongly developed layer of parenchyma which may become more or less sclerotic (*Dracaena*, stem).
  2b. vascular bundles imbedded in the parenchyma mentioned sub 2a: they may be collateral (*Chenopodium album*, *Salicornia herbacea*, all *Nyctaginaceae* etc., stem [1]) or amphivasal (*Dracaena*, stem).

S. No. 702. (cf. S. No. 636). Tissue systems. The following tissue systems may be distinguished:
1a. epidermal tissue system, epidermis or tegumentary system. This forms the surface of the plant. It generally arises from the outer cell layer of the meristem, but in exceptional cases it may be formed by cells of the fundamental tissue forming the surface where parts have been torn asunder (in the circumference of the holes in the leaves of *Scindapsus pertusus* or in the slits formed in *Palm* leaves). In the great majority of cases it consists only of a single cell layer, but sometimes more layers are formed by the formation of cell walls parallel to the surface (*Ficus elastica*, leaf, water-tissue; *Dendrobium nobile*, aerial root, velamen). It mostly consists of parenchyma but in a few cases of prosenchyma (*Theobroma cacao*, seed). It forms many kinds of appendages, especially trichomes. With the exception of the pores of stomata it is devoid of intercellular spaces. It is differentiated somewhat earlier than the inner tissues, and the outer and side walls, at least in the shoot, not in the root, have a strong tendency to thickening and cuticularisation.
The formation of organ-primordia and of secondary tissues in this tissue system are of limited occurrence. We may observe:
  2a. formation of organ-primordia.
    3a. in the stem. All organs with exogenous development (cf. S. No. 71) are partly formed by the epidermis of the stem in so far as the epidermis of the primordium is formed by the epidermis of the

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1) De Bary. Vergleichende Anatomie der Vegetationsorgane p. 608, English translation p. 590.

stem. All phyllomes, the great majority of caulomes, a very small minority of roots.

2b. cambial secondary tissue.

3a. in the root. Cork tissue in very rare cases (*Solidago* [1])).

3b. in the stem. Not infrequently. *Viburnum Lantana.*

2c. dilatation secondary tissue.

3a. in the stem. The persisting epidermis of *Acer striatum, Viscum album.* Examples of secondary dilatation growth without cell division are afforded by some Palms: *Actinophloeus propinquus.*

1b. ground tissue system or fundamental tissue system. Its outer side adjoins the epidermis, whilst its inner part adjoins the stelar system. It often forms the bulk of the organographical parts to which it belongs. It has a strong tendency to be constituted of thin-walled parenchyma and in these cases intercellular spaces usually occur and often may be large. Nevertheless in this parenchyma idioblasts and bundles of collenchymatous, sometimes also of sclerotic elements, are of very common occurrence. Its inner part, bordering on the stelar tissue system is called endodermis [2]), and consists mostly of a single layer of oblong parenchyma cells. The endodermis exhibits mostly a peculiar differentiation of various kinds in different parts of plants. Thus the endodermis may be developed as a protective sheath (cf. S. No. 632) (most roots), a starch-sheath (most stems), a protective sheath and starch-sheath combined, (*Menyanthes trifoliata*, leaf [3])), a sheath of sclereids (many roots, *Smilax spp.*), a crystal sheath (*Andropogon*, root) and a periderm sheath (*Gentiana lutea*, root). See S. No. 703.

The formation of organ-primordia and of secondary tissues in this tissue system are of rather limited occurrence. We may observe:

2a. formation of organ-primordia.

3a. in the root. Origin of endogenous rootlets in the endodermis (vascular Cryptograms [4])).

3b. in the stem. All organs with exogenous development (cf. 1a, 2a, 3a) are partly formed by the outer layers of the ground tissue system, as their ground tissue and stelar tissue systems are formed by it. Origin of endogenous rootlets in the endodermis (vascular Cryptogams).

2b. cambial secondary tissue.

3a. secondary cork tissue.

4a. in the root. In some cases: *Cycas, Monstera, Iris, Jasminum.*

4b. in the stem. In the great majority of cases (cf. S. No. 662).

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[1]) Ph. Van Tieghem, Traité de Botanique, 2nd. ed., Paris 1891, 1. p. 719.

[2]) The question might be raised whether the endodermis belongs to the ground tissue or to the stele. It seems to me that it is a matter of very small importance and that in both cases the conception of the terms ground tissue and stele remains intact. But it is a fact that botanists generally are used to considering the endodermis as belonging to the ground tissue and I see no reason to make an exception to this rule.

[3]) Moll and Janssonius, Botanical Pen-portraits, The Hague 1923, p. 200.

[4]) Van Tieghem l.c. p. 700.

4c. in the leaf. In very rare cases: bud-scales of *Aesculus Hippocastanum*, *Terminalia Catappa.*

3b. secondary vascular bundle tissue.

4a. in the root. *Dracaena fragrans,* in the inner ground tissue layers and in the endodermis.

4b. in the stem. *Dracaena,* in the endodermis.

2c. dilatation secondary tissue.

3a. in the stem. Parenchyma cells tangentially elongated and divided by radial cell walls: *Linum usitatissimum*; *Viburnum prunifolium*; *Oreodoxa regia.*

1c. stelar tissue system[1]), stele or central cylinder. In the principal parts of *Plerido-* and *Spermophyta* there is a tendency to form in a more or less central position a tissue system constituted of two parts:

1. a vasal part: bundles of xylem, phloem, vascular bundles or fibrovasal bundles; 2. a non-vasal, more parenchymatic part mostly mixed up with bundles of sclerenchyma fibres. This tissue system is of course ramified where the parts which contain it are ramified but when considering the non-ramified subdivisions of those parts, we find that it may exhibit either the shape of an unbranched solid cylinder or that it is branched even in these subdivisions, and in the latter case it may moreover be hollow and filled up with fundamental tissue. Intercellular spaces are wanting or mostly few and slightly developed in the outer parts of the stele, but in the middle part or pith they are of common occurrence and may be very large, even lysigenous (cf. S. No. 634). See S. No. 704.

The formation of organ-primordia, especially of roots, and of secondary tissues is very common and of the utmost importance in this tissue system. The principal cases are:

2a. formation of organ-primordia.

3a. in the root. Origin of rootlets in the pericycle, see S. 706

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[1]) For the conception set forth here the name Stelar Theory is often used. In doing so however it ought to be kept in mind that the word theory has here a sense different from that usually given to it pure science. Indeed if we use here the term stelar theory we may as well use those of epidermal theory, theory of secondary phloem and xylem, and even parenchymatic or sclerenchymatic theories, and certainly there are not many botanists who would be disposed to go this length.

Nevertheless it is true that when science is cultivated especially with a view to practical applications the term theory is sometimes used simply for indicating the knowledge of facts. Thus a military man may speak of studying the theory of the gun in contrast with his practical exercises in shooting. But when science is cultivated for its own sake it is better to speak of theory only in the sense of a hypothesis enabling us to see facts from a common point of view, which seemed quite independent from one another.

Van Tieghem was the first to recognize the importance of considering the central cylinder or stele as a tissue-system, equivalent to epidermis and ground tissue. He was also the first to use the term "Stelar theory" and the above remarks hold good for this case. But they do not imply the impossibility of the existence of a stelar theory in the better sense of the word. It may even be said that such a theory arises from the conception that several existing kinds of steles must be derived from a "protostele".

(*Gymno-* and *Angiospermae* in young roots) or in the secondary phloem (in older thickened roots); origin of adventitious shoots in the pericycle (*Gymno-* and *Angiospermae*, rather frequently) or in the secondary phloem (in older roots).

3b. in the stem. Origin of rootlets in the pericycle (*Gymno-* and *Angiospermae* in young stems) or in the secondary phloem (in older thickened stems); origin of adventitious shoots in the pericyle or in the secondary phloem.

2b. cambial secondary tissue.

3a. secondary cork tissue.

4a. in the root. In the pericycle (*Gymno-* and *Angiospermae*, frequently) or in the secondary phloem (in older thickened roots).

4b. in the stem. In the pericycle (*Ribes*, *Rhododendron*) or in the secondary phloem (in older thickened stems).

3b. secondary phloem and xylem.

4a. in the root. Normally in the medullary commissures inside the phloem bundles and outside the xylem-bundles. *Gymnospermae*, *Dicotyledonae*. In a limited number of cases in other parts; in the pericycle, in the secondary phloem, in the xylem parenchyma or in the pith; these cases are collectively called anomalous secondary growth. It occurs chiefly in lianas or in thick fleshy roots. *Mirabilis Jalapa*, *Beta vulgaris*, *Myrrhis odorata*.

4b. in the stem. Normally by the fascicular and the interfascicular cambium, see S. No. 715. *Gymnospermae* and *Angiospermae*. Anomalous secondary growth (cf. 4a) occurs in a limited number of cases, especially in lianas (*Gnetum scandens*, *Serjania*, *Tecoma*) though other plants may show the same phenomenon (*Cycas circinalis*).

3c. secondary vascular bundle tissue.

4a. in the root. *Dracaena fragrans*, in the pericycle.

4b. in the stem. *Dracaena*, in the pericycle.

2c. dilatation secondary tissue.

3a. the increase in girth in cambia of roots and stems [1]), either non-stratified or stratified (cf. S. No. 626) and producing either secondary cork tissue or secondary phloem and xylem. Of general occurrence.

3b. dilatation tissue in secondary phloem (cf. S. No. 699).

3c. dilatation tissue in secondary xylem. Only in rare cases, of a very complex anomalous secondary growth. *Anisostichus capreolata*.

3d. dilatation tissue in the inner parenchymatous part of the stele. *Helianthus annuus* [2]), medulla of stem; *Palmae* exhibiting secondary growth in their stems [3]), such as *Actinophloeus*, *Caryota*, *Oreodoxa* where the dilatation tissue is a result of active secondary growth without cell divisions, in the sheaths of the fibrosal bundles.

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[1]) J. J. Beyer, Die Vermehrung der radialen Reihen im Cambium, Recueil trav. bot. néerl. 24, 1927.

[2]) D. Thoday, On the organisation of growth and differentiation in the stem of the Sunflower, Annals of Botany 36, 1922, p. 489.

[3]) J. C. Schoute, Ueber das Dickenwachstum der Palmen, Ann. de Buitenzorg 26, 1912, p. 1.

S. No. 703. (cf. S. No. 702). According to the reciprocal disposition of ground tissue and stelar system and to the outward shape of the part containing it, the ground tissue system may be indicated in the ordinary course of micrography by the following terms:
1a. cortex. This term is used in describing voluminous, often more or less cylindrical not flattened parts, which moreover are monostelous (see S. No. 705). Most roots, stems and many petioles of leaves.
1b. mesophyll. This term is used in describing thin, flat parts which are mostly schizostelous (see S. No. 705). It is almost exclusively used for the blades of leaves, also in the more exceptional cases when these exhibit a more voluminous shape.
1c. ground tissue or fundamental tissue. This, at the same time the more general term, is used in describing voluminous or thin and flat parts in the following cases:
 2a. when voluminous parts are schizostelous (see S. No. 705). *Gunnera* and *Primula*, stem; many petioles of leaves; *Ferns*, rhizomes; *Equisetum*, many stems.
 2b. when the stelar tissue system is wanting. Many integuments and the endosperm of seeds; *Marchantia*, many *Algae* and *Fungi*, thallus; *Lycopodium*, prothallium.

S. No. 704. (cf. S. No. 702). Concerning the stele the following subjects will be dealt with:
1a. monostely and schizostely. See S. No. 705.
1b. subdivisions of the stele. See S. No. 706.
1c. xylem bundles, exarch, mesarch, endarch. See S. No. 707.
1d. phloem bundles, exarch, endarch. See S. No. 708.
1e. cauline, foliar and leaf-trace vascular bundles. See S. No. 709.

S. No. 705. (cf. S. No. 704). With respect to ramification and disposition of the stele we may distinguish:
1a. monostely and monostelous parts. The stele in non-ramified subdivisions of the plant is unbranched and solid and occupies a truly central position. Most roots, stems and many petioles of leaves.
1b. schizostely and schizostelous parts. The stele in non-ramified subdivisions of the plant is branched and may be hollow. The branches often do not exhibit the complete radial stelar structure (see S. No. 706) which is found in monostelous organs and those branches are called meristeles. *Primula* and *Gunnera*, stem; most *Ferns*, rhizome; most leaf blades of the higher plants.

S. No. 706. (cf. S. No. 704). In a complete stele, such as often is found in roots and in dicotyledonous stems, we may distinguish:
1a. bundles of vasal elements containing as their chief constituents at least one kind of vessel. Those bundless may be developed as separate xylem or phloem bundles, alternating with one another (in roots), but also as vascular bundles or fibrovasal

bundles and are always embedded in the peripheral part of the non-vasal portion of the stele and generally arranged in a ring. This arrangement is to be found also in the early phase of those steles exhibiting in a fully developed state a scattered disposition of the bundles, as is the case in monocotyledonous stems; in consequence of a strong growth in thickness in the meristematic state the original arrangement is disturbed here. When there are vascular bundles they may be closed or open and in the latter case they contribute largely to the formation of secondary xylem and phloem.

1b. the non-vasal or more parenchymatic portion of the stele, in which the bundles are embedded. This consists of:

2a. pericycle or pericambium. The tissue between the endodermis and the ring of bundles. It often consists only of a single layer of thin-walled parenchyma cells (*Vicia Faba*, root), but may also be much thicker (*Cucurbita Pepo*, stem) and is often provided with or entirely consisting of sclerenchyma fibres, sometimes without lignified walls (*Linum usitatissimum* and *Cinnamomum Zeylanicum*, stem); it may also contain sclereids.

The pericycle may give rise to many organ-primordia and to various secondary tissues (cf. S. No. 702).

2b. medullary commissures. The tissue between the vasal bundles; they are in connection with the pericycle and if a pith is present with the pith. They mostly take part in the formation of secondary phloem and xylem (cf. S. No. 702).

2c. pith. The central part of the stele within the ring of bundles and united by the medullary commissures with the pericycle. It may be developed more or less, very large (*Sambucus nigra*, stem) or even totally wanting (*Sphenophyllum plurifoliolatum*, stem; *Vicia Faba*, root) when its place is taken by primary xylem. Its chief constituent is thin-walled parenchyma, the cells of which may sometimes die and become filled with air, but moreover sclereids and other elements may occur and it is sometimes provided with longitudinal phloem bundles (*Solanaceae* stem, leaf). It often exhibits intercellular spaces, which may become very large and even lysigenous so that wide pith-cavities may be formed (*Helianthus annuus*, stem). Formation of primordia or secondary tissues does not occur in the ordinary course of things.

S. No. 707. (cf. S. No. 704). In xylem bundles, with respect to the reciprocal position of proto- and metaxylem we may distinguish:

1b. exarch primary xylem. The protoxylem is turned outwards towards the periphery of the stele; the metaxylem is turned inwards and is termed centripetal. All roots; *Lycopodium*, stem.

1b. mesarch primary xylem. The protoxylem lies in the middle and metaxylem has developed not only towards the centre of the stele but also towards its periphery; the latter metaxylem is called centrifugal. *Cycadaceae*, petiole.

1c. endarch primary xylem. Protoxylem turned inwards towards the centre of the stele, whilst the metaxylem is turned towards the periphery and is centrifugal. Higher *Gymnosperms*, *Angiosperms*, stem.

S. No. 708. (cf. S. No. 704). In phloem bundles, with respect to the reciprocal position of proto- and metaphloem, we may distinguish:
1a. exarch primary phloem. The protophloem is turned outwards towards the periphery of the stele; the metaphloem is turned inwards and is termed centripetal. *Dicotyledons*, stem.
1b. endarch primary phloem. The protophloem is turned inwards towards the centre of the stele; the metaphloem is turned outwards and termed centrifugal. *Marattiaceae*, stem.

S. No. 709. (cf. S. No. 704). Among vascular bundles, with respect to their longitudinal extension, we may distinguish:
1a. cauline bundles. They belong solely to the stem. *Pteridophyta*, *Begonia*, *Aralia*, stem.
1b. foliar bundles. They coalesce at once with other bundles when entering the stem and have no independent existence there. *Pteridophyta.*
1c. common bundles or leaf-trace bundles. They are common to both leaf and stem, and passing into the stem they form within the latter so called leaf-traces, composed of one or more vascular bundles (one-strand- up to many-strand-leaf-traces). Most *Gymnosperms* and *Angiosperms.*

B. Special Histology.

S. No. 710. (cf. S. No. 552). Concerning special histology the following subjects will be dealt with:
1a. subject-matter of special histology. See S. No. 711.
1b. caulome. See S. No. 712.
1c. phyllome. See S. No. 717.
1d. stamen. See S. No. 721.
1e. pistil. See S. No. 722.
1f. root. See S. No. 723.
1g. appendages of the surface. See S. No. 730.

S. No. 711. (cf. S. No. 710). Subject-matter. The object of the synopsis is to explain the meaning of all botanical terms generally used in phytography and not to give the reader a more or less complete morphological image of the vegetable kingdom. It is indeed true, that in working out this object a great mass of materials has been brought together, suitable for the composition of such a description, and even that in some respects and in some parts a rather complete description has been the consequence. But it would far surpass the boundaries of this synopsis completely to describe the histology of certain important organs, like caulome, phyllome or root. On this head a few short notices must suffice and it is chiefly designed here to explain some peculiar terms used only for these special parts. There is even no paragraph dealing with the thallome, because some terms which might have been considered here, have been sufficiently explained in organography. Concerning the appendages of the surface however an exception has been made. The relatively simple histological structure of these organs has been worked out somewhat more in detail, because it often leads to a better understanding of the terms used in organography, concerning these organs.

S. No. 712. (cf. S. No. 710.) Caulome. Concerning the caulome the following subjects will be dealt with:
1a. length of endodermis cells. See S. No. 713.
1b. distribution of vascular bundles. See S. No. 714.
1c. fascicular and interfascicular cambium. See S. No. 715.
1d. medullary sheath or medullary corolla. See S. No. 716.

S. No. 713. (cf. S. No. 712). In dicotyledonous stems the endodermis generally consists of parenchyma cells exhibiting one half of the length of the adjoining cells on its outside and inside.

S. No. 714. (cf. S. No. 712). The vasal parts of the stele in a stem consists of vascular bundles. With respect to the distribution of these bundles we may distinguish:
1a. the dicotyledonous arrangement. They are placed in a ring.
1b. the monocotyledonous arrangement. They are scattered through the non-vasal part of the stele, more numerous and thinner towards the periphery, less numerous and thicker towards the centre (cf. S. No. 706).

S. No. 715. (cf. S. No. 712). When a stem is about to form secondary xylem and phloem there is first formed a cylindrical cambium layer, in which we may distinguish:
1a. the fascicular cambium. The parts formed in the simple vascular bundles between phloem and xylem. They throw off:
  2a. fascicular phloem. On the outside.
  2b. fascicular xylem. On the inside.
1b. the interfascicular cambium. The parts formed in the medullary commissures, as well in those between the simple as in those between the compound bundles. These parts of the cambium may also be formed in the parts of the pericycle, corresponding with the medullary commissures. (cf. S. No. 706). They throw off:
  2a. interfascicular phloem. On the outside.
  2b. interfascicular xylem. On the inside.

In cases of anomalous secondary growth (cf. S. No. 702) cambia may appear in the cortex, in the endodermis, in the pericycle, in the secondary phloem, in the secondary xylem or in the pith. In some cases they show inverse orientation, throwing off xylem to the outside and phloem to the inside (*Rheum* sp. rhizome).

S. No. 716. (cf. S. No. 712). In stems showing secondary xylem the term medullary sheath or medullary corolla is used to designate the primary xylem portions of the original vascular bundles. They seem to project into the medulla, but in fact are separated from one another by the innermost portions of the original medullary commissures.

S. No. 717. Phyllome. (cf. S. No. 710). Concerning the phyllome the following subjects will be dealt with:
1a. distribution of stomata. See S. No. 718.
1b. collecting or receiving cells in mesophyll. See S. No. 719.
1c. occurrence of steles and meristeles. See S. No. 720.

S. No. 718. (cf. S. No. 717). With respect to the distribution of the stomata we may distinguish:
1a. hypostomatal leaves. All stomata are placed on the lower surface of the leaf. *Erythroxylum Coca.*
1b. epistomatal leaves. All stomata are placed on the upper surface of the leaf. *Nymphaea alba.*
1c. amphistomatal leaves. The stomata are placed both on the upper and on the lower surface of the leaf. *Digitalis purpurea.*

S. No. 719. (cf. S. No. 717). In the mesophyll of leaves we may often distinguish collecting cells or receiving cells. They are expanded cells of the spongy chlorenchyma adjoining the palisade chlorenchyma and each in contact with the converging lower ends of a group of palisade chlorenchyma cells.

S. No. 720. (cf. S. No. 717). In leaves complete steles are relatively rare (*Pilocarpus Jaborandi,* midrib [1]) and meristeles are of most common occurrence. The vasal part of the stele here consists of vascular bundles, as in the stem.

S. No. 721. (cf. S. No. 710). Stamen. In the walls of the thecae of the anthers we may distinguish the following layers:
1a. the epidermis.
1b. the fibrous layer or layer of fibrous cells. Mostly a single cell layer, but in some parts of the wall it may consist of a few cell layers; the cell walls show partial thickenings, mostly bandshaped and perpendicular to the outer surface.
1c. the intermediate parietal layer. Often disappearing when the pollen ripens.
1d. the tapetum or tapetal layer. It is used up during the formation of pollen.

S. No. 722. (cf. S. No. 710). Pistil. In pistils the epidermis lining the internal cavity may form a conductive or conducting tissue, through which the pollen-tube finds its way towards the egg cell. It consists of parenchyma with swollen walls and may be present in the stigmata, style and ovary.

S. No. 723. (cf. S. No. 710). Root. Concerning the root the following subjects will be dealt with:

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[1]) Botanical Pen-portraits p. 175.

1a. calyptra. See S. No. 724.
1b. root-sheath or velamen radicum. See S. No. 725.
1c. exodermis. See S. No. 726.
1d. monarch, diarch, triarch, etc. roots. See S. No. 727.
1e. isostic and diplostic root branches. See S. No. 728.
1f. phloem and xylem arches of cambium. See S. No. 729.

S. No. 724. (cf. S. No. 723). In the calyptra or root-cap we may distinguish:
1a. the columella. The more or less cylindrical central living portion consisting of thin-walled parenchyma, which mostly contains numerous plastids with relatively large starch grains.
1b. the outer part. Consisting of more or less obliterated and often ultimately exfoliating parenchyma.
1c. the calyptrogen or calyptra cambium. A special cambium for the formation of the root-cap. *Zea Mays.*

S. No. 725. (cf. S. No. 723). The epidermis may be developed into a velamen, root-sheath or velamen radicum, i.e. a dead water tissue (see S. No. 566 and 637) consisting of several layers of reticulate parenchyma cells. Many *Orchideae* and *Aroideae,* aerial roots.

S. No. 726. (cf. S. No. 723). In many roots the epidermis soon dies and disappears. The outermost cortical layer takes its place and is developed into an exodermis, which may be differentiated as:
1a. the primary cork layer. Developed as a periderm. *Valeriana officinalis.*
1b. a layer of sclereids. *Smilax spec.*
1c. a protective sheath. *Dendrobium nobile,* aerial root.

S. No. 727. (cf. S. No. 723). The vasal part of the stele in a root consists of isolated xylem and phloem bundles, placed in a ring and alternating with one another. The number of each kind of bundle may vary from one up to many. With respect to this number we may distinguish:
1a. monarch roots. With one xylem and one phloem bundle. *Selaginella, Isoetes.*
1b. diarch roots. With two xylem and two phloem bundles. *Taxus baccata, Taraxacum officinale.*
1c. triarch roots. *Glycyrrhiza glabra.*
1d. tetrarch roots. *Vicia Faba.*
1e. polyarch roots. *Acorus calamus.*

S. No. 728. (cf. S. No. 723). Isostic and diplostic root branches[1]). The arrangement of root branches placed in ortho-

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[1]) Ph. Van Tieghem, Recherches sur la disposition des radicelles et des bourgeons dans les racines des Phanérogames. Ann. des sciences nat, Bot. 7 sér., t.V, 1887, p. 130.

stichies on the mother-root shows a correspondence with the anatomical structure of the mother-root and in this respect we may distinguish:
1a. isostic root branches. The number of orthostichies is the same as that of the xylem bundles in the mother-root, because the root branches appear each on the outside of a xylem bundle. This case chiefly occurs in roots possessing more than two xylem bundles. *Vicia Faba*, branching of primary root; *Beta vulgaris* (only two xylem bundles).
1b. diplostic root branches. The number of orthostichies is double that of the xylem bundles in the mother-root, because the root branches are placed on radiï, lying between the xylem and phloem bundles. This case is limited in its occurrence to roots possessing only two xylem bundles. *Artemisia*; *Madia*; *Lupinus*; *Ononis*; *Polanisia.*

S. No. 729. (cf. S. No. 723). When a root is about to form secondary xylem and phloem there appears first a cambial strip in the parenchymatic portion of the stele on the inside of each phloem bundle; these strips extend towards both sides in the medullary commissures and soon afterwards the cambium ring is completed by the formation of cambium in the pericycle just outside the xylem bundles; usually by the progress of growth the original sinuous shape of the cambium ring soon disappears and a cylindrical cambium ensues, though in rare cases the sinuous shape of the cambium may persist (*Aconitum Napellus*, root tuber). In connection with this mode of formation we may distinguish:
1a. the phloem arches of the cambium. The parts on the inside of the phloem bundles.
1b. the xylem arches of the cambium. The parts on the outside of the xylem bundles.

S. No. 730. (cf. S. No. 710). Appendages of the outer surface and the surfaces of internal cavities. Concerning the appendages the following subjects will be dealt with:
1a. lack of correspondence between organographical terms and anatomical structure. See S. No. 731.
1b. subsidiary cells. See S. No. 732.
1c. uni- and pluriseriate appendages. See S. No. 733.
1d. file appendages. See S. No. 734.
1e. capitate appendages. See S. No. 735.
1f. glandular appendages, cuticular bladder. See S. No. 736.
1g. trichomes and emergences. See S. No. 737.
1h. anatomical characters of appendages and their representation in the special kinds of appendages distinguished in organography. See S. No. 738.

S. No. 731. (cf. S. No. 730). The terms enumerated in organography for the appendages will be used here, but it will be found that the anatomical structure does not always correspond to the organographical character. In several cases appendages belonging to the same organographical division are different in their anatomical structure and are consequently indicated by different anatomical terms. Thus we may distinguish bristle trichomes and bristle emergences, prickle trichomes and prickle emergences. See S. No. 737 and 738.

S. No. 732. (cf. S. No. 730). The cells of the surface, surrounding an appendage, may be arranged in a ring or in radiating lines or may be otherwise different from ordinary surface cells. They may be called subsidiary cells to the appendages. *Cannabis indica,* leaf epidermis [1]). Confer moreover S. No. 641.

S. No. 733. (cf. S. No. 730). In more or less cylindrical appendages, with respect to the number of longitudinal cell rows constituting them, the following terms may be used: uniseriate, biseriate, triseriate up to multiseriate.

S. No. 734. (cf. S. No. 730). File appendages. Their surface exhibits numerous small knobs, mostly protuberances of the cuticle and sometimes containing small crystals of calcium oxalate (*Nymphaea alba,* petiole, internal hairs). See S. No. 738.

S. No. 735. (cf. S. No. 730). Concerning capitate appendages (cf. S. No. 449) the following terms are used:
1a. the basal part. It consists of one or more cells and is mostly more or less embedded in the tissue bearing the appendages.
1b. the stalk. It may consist of one or more up to a large number of cells.
1c. the head. It may consist of one or more up to a large number of cells.

S. No. 736. (cf. S. No. 730). Concerning the anatomy of glandular appendages it may be said that they are provided with glandular cells (cf. S. No. 567), mostly forming the head of the appendage. The excreted products may often be collected between the cuticle and the adjacent part of the outer walls and thus cuticular bladders may appear containing the excreted substances; ultimately these cuticular bladders may be ruptured, setting free the excreted substances and afterwards a new cuticular bladder may be formed. See S. No. 737 and 738.

S. No. 737. (cf. S. No. 730). With respect to their anatomical origin we may distinguish:
1a. trichomes. Appendages produced by the most superficial cell layer. This may often be the epidermis, but in cases of intercellular cavities it belongs to another tissue system (*Nymphaea alba,* petiole, internal hairs in air passages). See S. No. 738.

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[1]) Botanical Pen-portraits, p. 285.

1b. emergences. Appendages produced not only by the superficial, but also by underlying cell layers and sometimes even containing portions of the stelar tissue system. See S. No. 738.

S. No. 738. (cf. S. No. 730). Survey of the anatomical characters exhibited by appendages of the surface and representation of these characters in the several special kinds of appendages, distinguished in organography (cf. S. No. 450).

1a. trichomes. (cf. S. No. 737).

2a. papillae. They are unicellular and mostly not separated by a transverse wall from the epidermal cell which produces them.

3a. ordinary papillae. *Viola tricolor*, petal; *Pellionia velutina*, leaf, upper side; *Prunus amygdalus*, seed.

3b. stigmatic papillae. Their walls have a tendency to form a mucilage, covering the stigmata. *Crocus vernus*; *Lilium Martagon* (sometimes divided by a transverse wall).

3c. capitate papillae. They are separated by a wall from the epidermal cell, and may be moreover file papillae. *Mesembryanthemum crystallinum*, leaf.

2b. hairs. They are separated in the great majority of cases by transverse walls from the superficial cells which produce them.

3a. ordinary hairs.

4a. unicellular. (*Rubus Idaeus*, fruit; *Gossypium herbaceum*, seed) or pluricellular (*Lavandula vera*, calyx).

4b. non-ramified (*Origanum Majorana*, leaf) or ramified (*Lavandula vera*, calyx).

4c. uniseriate (*Carbenia benedicta*, leaf) or pluriseriate (*Hieracium aurantiacum*), if biseriate sometimes called twin-hairs (*Arnica montana*, ovary) [1].

4d. file hairs. (*Justicia magnifica*, leaf; *Nymphaea alba*, internal hairs of petiole).

3b. balance hairs. Uni- or pluricellular.

4a. ordinary. *Artemisia Absinthium*, leaf (pluricellular); *Sapotaceae*. [2]).

4b. file balance hairs. *Nymphaea alba*, peripheral part of petiole, internal hairs in narrow intercellular passages (unicellular).

3c. stellate hairs. Unicellular, pluricellular or file hairs. *Deutzia scabra*, leaf (unicellular); *Althaea officinalis*, leaf (pluricellular); *Nymphaea alba* and *Nuphar luteum*, petiole, internal hairs in wide intercellular passages (unicellular, file hairs).

3d. clinging hairs. They are unicellular and provided with more or less thickened cell walls. *Rubia tinctorum*, *Humulus Lupulus*, stem.

3e. collecting hairs or brush-like hairs of style. They are unicellular and not divided by a transverse wall from the epidermal cell producing them, in so far resembling papillae. *Compositae*: *Centauria phrygia*; *Sphaerocephalus*.

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[1] Botanical Pen-portraits, p. 132.

[2] F. H. Endert, Geslachtstabellen voor Nederlandsch-Indische boomsoorten naar vegetatieve kenmerken etc. Dissert. Wageningen Agricultural High School 1928. p. 78 and 81.

3f. stings or stinging hairs. They consist of the following parts:

4a. a large conical cell. The chief part of the hair, with a small head, just below which the cell wall remains very thin. This large cell is set with its base in:

4b. a socket. Multicellular and formed by the epidermis. Examples: *Urtica urens*; *Laportea gigas*; *Loasaceae*, leaves.

3g. capitate hairs. (cf. S. No. 735).

4a. not glandular or ordinary capitate hairs. They are not provided with glandular cells. *Datura Stramonium*, leaf.

4b. glandular capitate hairs. (cf. S. No. 736).

5a. ordinary glandular hairs. They are uni- or pluricellular and often provided with a cuticular bladder. *Oenothera biennis*, leaf (without cuticular bladder); *Aspidium Filix mas*, hairs in intercellular spaces of rhizome; *Primula obconica*, peduncle; the latter two examples with a cuticular bladder.

5b. glandular hairs, type of Labiatae. They are multicellular exhibiting a basal part and a stalk, both uni- up to pluricellular. Their head consists of a single horizontal layer of cells, at least eight in number, but often these cells become sub-divided and thus it may exhibit a large number of cells; the head always provided with a cuticular bladder. *Mentha piperita*, leaf; *Juglans regia*, leaf; *Cannabis sativa*, perigon; *Humulus Lupulus*, scales of cone.

5c. glandular hairs, type of Compositae. They are not strictly capitate, but exhibit about four stories, each mostly consisting of two cells and in a few instances only of a single cell; the cells of the upper two or three stories are glandular with a cuticular bladder and may be considered as the head. *Matricaria Chamomilla*, ovary; *Carbenia benedicta*, leaf (head consisting of some single celled stories [1])).

5d. colleters. These are the glandular hairs occurring on many bud-scales and producing blastocolla, a mucilaginous more or less resinous substance. They have a thick multicellular head and a cuticular bladder. *Aesculus Hippocastanum*, outside of bud-scales.

3h. root-hairs. In the great majority of cases, they are unicellular and not separated by a transverse wall from the epidermal cell producing them, in this respect resembling papillae; the outer layers of their cell walls have a tendency to become mucilaginous and thus particles of earth may be glued to them. *Pteridophyta*, *Gymno-* and *Angiospermae*. In a few cases however they may be pluricellular, uniseriate, for instance in *Marattiaceae* and *Psaronius* [2]).

4a. rhizoids. They are often unicellular. For instance:

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[1]) Botanical Pen portraits, p. 295.

[2]) J. C. Schoute, in: The foliar origin of the internal stelar structure of the Marattiaceae. Recueil trav. bot. néerlandais t. 23, 1926, p. 269 (in a footnote on p. 298).

Aspidium Filix mas, gametophyte; *Psilotum*, rhizome; *Rhynia*, rhizome; *Marchantia polymorpha*, thallus. In other cases however they are multicellular, as in *Musci*.

4b. rhizines. They are of hyphal origin and often pluricellular. *Lichens*.

2c. haptere-appendages. Root hairs. *Podostemaceae*.

2d. haustoria-appendages. (cf. S. No. 75). They are unicellular. *Phytophthora infestans*.

2e. epidermal emissaries or trichome emissaries. Pluricellular. *Phaseolus multiflorus*, leaf.

2f. bristle trichomes. They are multicellular. *Papaver Rhoeas*, stem.

3a. awn or beard. Pluricellular. *Gramineae*.

2g. prickle trichomes. They are multicellular and sclerotic. *Rubus spp.*, stem; *Ilex Aquifolium*, leaf.

2h. scurves or scales.

3a. ordinary scurves. Unicellular, though divided by partial cell walls, radiating from the periphery. *Croton eluteria*; *Elaeagnus*; *Hippopphaë rhamnoides*, leaf.

3b. ramenta. Mostly multicellular. *Aspidium Filix mas*; *Davallia dissecta*.

2i. paraphylls. They are pluricellular. *Musci* e.g. *Climacium dendroides*.

2j. indusia of certain sori. They are multicellular. *Aspidium Filix mas*.

2k. paraphyses. They are uni- of pluricellulair. *Fucus*, unicellular; *Hymenomycetes* and *Ascomycetes*, unicellular; *Aspidium Filix mas*, pluricellular; *Marchantia polymorpha*, unicellular; *Musci*, pluricellular.

3a. cystids. They are unicellular. *Russula rubra*.

3b. periphyses. *Podospora fimiseda*.

1b. emergences.

2a. bristle emergences. *Dionaea muscipula*, margin of leaf; *Drosera*, tentacles of leaf, being capitate and glandular emergences, provided with a meristele.

2b. prickle emergences. *Rosa gallica*, stem.

2c. fruit-pulp emergences. *Citrus vulgaris*, internal surface of pericarp.

APPENDIX TO SECTIONS II AND III. ILLUSTRATIONS.

S. No. 739. As a complementary means of giving a representation as complete as possible of the forms of plants, in many cases drawings or models, accompanying pen-portraits, may render great service. Amongst them we may distinguish:
1a. pictures. See S. No. 740.
1b. plastic models. See S. No. 741.
1c. diagrams. See S. No. 742.

S. No. 740. (cf. S. No. 739). Pictures. There is a certain contrast between descriptions and pictures; the latter being subject to several drawbacks. One of these is their one-sidedness in the most literal sense of the word, only partially to be met with by giving several aspects. Another, and still more serious drawback is that a picture can only represent a single individual, so that all kinds of generalization are radically prevented. Nevertheless for obtaining really complete records concerning a plant, pictures are absolutely necessary, and descriptions, however elaborate, are never sufficient. This is caused by the fact that we can express in words only things which have passed through the human mind and have come to a certain intelligibility, at least in so far as they have been linked more or less to other conceptions.

Every thing however which can be the subject of phytography exhibits not only characters fit for being expressed in words, but also a number of characters which have not yet been understood, so that they are unattainable for human language. This does not mean that they are of secondary importance, for a single glance at a simple drawing or photograph of the same object, or the reminiscence of having seen the object itself before will often afford what could not be reached by the most elaborate description. The object can now be recognized, or if this had already taken place, important characters will be added to the image. This holds good not only for descriptions of the external organisation, but also for those of anatomical structures, where for example the spatial relations between several tissues cannot be expressed in words. Therefore for instance in the book entitled: Moll and Janssonius, Botanical Pen-portraits, simple drawings have been added to most articles. But it is clear that for attaining the end sketched above, only pictures of perfect fidelity and accuracy are of value, such as can be acquired by photography or by drawing from nature. In the latter case microscopic objects or sections must be sketched with the camera lucida and finished with the help of continual control through the microscope.

It is certainly true that there is a strong contrast between modern literature concerning systematical botany and that of three hundred years ago. Consulting the works of Dodonaeus and others we find a profusion of beautiful pictures, accompanied by short and for us incomplete verbal descriptions. Since Linné our art of describing has been greatly developed, so that even for many purposes pictures have become superfluous, but for full records they remain indispensable, because in many respects even the simplest plant shows essential, but unintelligible particulars. For the time being, such particulars therefore remain in the domain of pictures as far as records are concerned, and in the domain of "habit" not to be expressed in words as far as the human mind is concerned. Happily men of genius studying such semi-occult phenomena may sometimes come to unexpected and interesting results by their power of intuition.

A. De Candolle in his "Phytographie", p. 312, seq. fully dealt with the subject, with which we are here concerned. In the preface to the book Moll and Janssonius, Botanical Pen-portraits, I referred the readers to De Candolle's interesting expositions and in most respects agreed with his opinion. On comparison the reader will find that although fully recognizing the importance of De Candolle's views, I have nevertheless come to a somewhat altered opinion with regard to the value of ordinary pictures.

The colouring of pictures is not a very important feature. It is very difficult to reproduce colours truly in print while on the other hand there are several excellent methods enabling the phytographer to mention them in his descriptions, and for this purpose the reader is referred to the synopsis No. 34.

Without disavowing what has been said above concerning the value of drawing, I must however acknowledge that before what has been told above was known to me, I used with success drawing as a mode of investigation. Making for instance a study of nuclear division, I used in my younger days to make many drawings, not for the purpose of illustrating my descriptions, but only in order to become thoroughly acquainted with my objects and found that this led me to good results. At present however I would begin in such cases with making pen-portraits.

S. No. 741. (cf. S. No. 739). Plastic models. Obviously these models are not suffering from the drawback of one-sidedness, but in all other respects they may be compared with pictures, so that the reader may be referred to the preceding article. They are however very restricted in number, so that perhaps against a single model thousands of pictures may be produced. Their use is chiefly indicated in cases where small objects exhibit a rather complex shape [1]) which presents difficulties against verbal explanation. By far the largest part of all plastic models however are not made for completing a scientific record, concerning some plant, but solely for educational purposes. Models of this kind representing flowers, *Fungi* and other objects exist in great numbers and are very useful for their own purposes, but need not to be dealt with in this work.

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[1]) Thus Dr. K. Zijlstra, in the botanical Laboratory at Groningen modelled in clay the foliage leaves of *Azolla filiculoides*, with their complex external differentiation, which proved difficult to express in words. Of this object a certain number of plaster-casts were made, most of which were sent to other laboratory-directors who wished to possess them.

S. No. 742. (cf. S. No. 739). About diagrams the following subjects will be dealt with:

1a. meaning of the term. See S. No. 743.
1b. empirical and theoretical diagrams. See S. No. 744.
1c. directions and principal uses of organographical diagrams. See S. No. 745.

S. No. 743. (cf S. No. 742). Diagram, meaning of term. This term will be used here for designating simplified schematic drawings for illustrating scientific descriptions of plants (phytographs), being deductions from these descriptions and by no means ordinary pictures independent from scientific botanical considerations.

The use followed here is in accordance with the general usage of the term in English botanical literature for indicating a schematic drawing in which much detail has been omitted in order to make clear some special point, while the drawing is often purposely made deviating from nature in some respect, when this can be of any advantage for the understanding of those features for which the diagram was made.

In German botanical literature the word "Diagramm" often has a more restricted meaning, in consequence of historical facts. The two great masters of diagrammatic art, Al. Braun and Eichler, did not make use of the term in the above sense. Braun did not use it at all, but spoke of "Schemata" and of "Blütenrisse", i.e. organographical transverse floral diagrams. Eichler confined the meaning of the term diagram to these same transverse floral diagrams and used as a German equivalent the term "Grundriss". Longitudinal diagrams were never called diagram by him, but only "Aufriss", a word which is difficult to translate.

Both Braun and Eichler often introduced into their organographical diagrams characteristic particulars, e.g. details of shapes and appendages of the surface of the plants. By these additions the figures are by no means deprived of their diagrammatic character. The additions are indeed traits belonging to ordinary artistic pictures and could have been omitted, but they give a certain liveliness which can be very well tolerated; they always conform to good taste and may be considered as a certain power of heightening the artistic effect by means of small transgressions against the ordinary valid rules, like dissonants in music.

Finally we may point to the fact that the majority of botanical diagrams has an organographical character, while anatomical diagrams are chiefly restricted to the illustration of the course of vascular bundles. In the following articles the organographical diagrams will therefore be treated in some detail.

S. No. 744. (cf. S. No. 742). With respect to the parts present in diagrams we may distinguish:
1a. the empirical diagram, exhibiting only the parts as observed in the plant.
1b. the theoretical diagram, exhibiting moreover parts which are not present in the plant itself, but the insertion of which may be useful for the understanding of the plant structure from a developmental, comparative morphological or phylogenetical point of view.

S. No. 745. (cf. S. No. 742). With respect to their direction we may distinguish amongst organographical diagrams:
1a. transverse diagrams. They represent a transverse section of the parts of the plant under consideration. Lateral appendages (phyllomes, lateral branches) are drawn as in a section transverse to their own longitudinal axis, as if they had been bent upward so as to become parallel to the principal organ. All parts are given as sectioned at such a level as may give most information about their peculiar properties. Whether the levels at which different parts are drawn correspond in the natural object, is disregarded; foliage leaves e.g. are drawn by preference as cut through the middle of their blades and at the same time through their stipules.

Transverse diagrams are largely made use of, as they express easily the more important organotactical properties of the plant.

Transverse organographical diagrams are in use for:
2a. floral diagrams, see S. No. 746.
2b. diagrams of inflorescences, see S. No. 747.
2c. diagrams of vegetative parts, see S. No. 748.
1b. longitudinal diagrams. They represent the part of the plant either as in lateral view, or in longitudinal section, or again in the case of cylindrical parts, sometimes as unrolled.

Longitudinal diagrams are less used, because they are less fit for expressing organotactical properties; they are indispensable however in such cases where the different levels of one organ are to be represented, and they may often be very instructive for picturing plastic properties.

Longitudinal organographical diagrams are in use for:
2a. floral diagrams, see S. No. 749.
2b. diagrams of inflorescences, see S. No. 750.
2c. diagrams of vegetative parts, see S. No. 751.

S. No. 746. (cf. S. No. 745). Transverse floral diagrams, the diagrams proper of Eichler, ought to indicate:
1a. the junction of the flower to the highest phyllomes of the cormus-individual under the flower (cf. S. No. 270); in a lateral flower

moreover the position with respect to the subtending leaf and the parent axis.
1b. presence, number and arrangement of all floral members (spiral, cyclic, alternating, superposed) and of their characteristic parts. The floral receptacle and a single style are generally omitted, as their representation would interfere with that of the ovary; if there are more styles and stigmas these are drawn as expanded horizontally from the ovary.
1c. aestivation and vernation of the perianth.
1d. the symmetry of the flower, and if present, the position of a plane of zygomorphy.

The value of the diagram may be heightened by introducing particular organotactical or plastic characters: number of thecae, side to which anthers open, discus formations, position and number of ovules, etc. Students wishing to exercise themselves in the diagrammatical art, will find on Plate 1 a collection of different floral diagrams copied without alteration from Eichler's classical work "Die Blüthendiagramme", Leipzig 1875—'78. They will find there examples of the most different kind which will show them how to express in a good style the varied phenomena.

S. No. 747. (cf. S. No. 745). Transverse diagrams of inflorescences, ought to contain:
1a. the position of the inflorescence with respect to the highest phyllomes of the cormus-individual under the inflorescence; in the case of a lateral inflorescence moreover with respect to the subtending phyllome and the parent axis.
1b. the phyllotaxis of the different cormus-individuals of the inflorescence, including the mode of junction of the flowers.
1c. the relation of the different cormus-individuals to the subtending bracts.
1d. the position of planes of zygomorphy, if present.

They are especially useful in the case of the dichasium (see pl. II fig. 3, c), the cincinnus and the screw.

The value of the diagram may be heightened by introducing particular organotactical or plastic characters: shape of different bracts, of peduncle and pedicels, of sympodial axis if present, etc.

S. No. 748. (cf. S. No. 745). Transverse diagrams of vegetative parts ought to contain:
1a. the phyllotaxis of the different cormus-individuals, including the junction to the cotyledon(s) or the prophyll(s).
1b. aestivation and vernation of the phyllomes.
1c. the relation between the different cormus-individuals and special phyllomes of their parent axes, if present.
1d. the position of planes of zygomorphy, if present.

For examples see plate II fig 3 A, B, III fig. 1.

The value of the diagram may be heightened by introducing particular organotactical or plastic characters; shape of phyllomes, of caulomes, of sympodial axes if present, etc.

S. No. 749. (cf. S. No. 745). Longitudinal floral diagrams ought to contain:
1a. indications of the form and orientation of the floral receptacle, the perianth, the stamens, the pistil, including placentae and ovules.

They are especially useful for representing peri- and epigynous flowers, and flowers with a peculiar form of floral receptacle. See plate IV fig. 2 and 4. They are further capable of representing the adnation of floral parts.

S. No. 750. (cf. S. No. 745). Longitudinal diagrams of inflorescences ought to contain indications of the mode of ramification and of the form and orientation of the peduncle, pedicels and bracts, and of sympodial axis if present; the adnation of parts may further be represented.

They are very useful in the case of the head, the raceme, the spike, the umbel, the coenanthium, the sickle and the fan, though they may be used for other inflorescences too. For examples see plate IV fig. 1 and 3. They may take part in the representation of the simple alternation of generations, see S. No. 751.

S. No. 751. (cf. S. No. 745). Longitudinal diagrams of vegetative parts ought to contain indications of the mode of ramification and of the form and orientation of the caulomes and phyllomes.

They are especially useful for representing the design on the stem surface, in which case the surface may be represented as unrolled (see pl. II, fig. 2) and moreover, if necessary, combined with longitudinal diagrams of the inflorescence, for the representation of the simple alternation of generations. As examples of the latter see pl. III, fig. 3, IV, fig. 5, V, VI, VII. These figures are faithful reproductions of different examples on the tables of Alexander Braun's paper, Das Individuum der Pflanze in seinem Verhältniss zur Species. Generationsfolge, Generationswechsel und Generationstheilung der Pflanze, 1853. They were drawn by C. Braun, the author's daughter, under the supervision of her father.

From her pen there appeared also a very interesting biography of her illustrious father, which deserves to be perused by all botanists ¹). It is here perhaps the place to direct the reader's attention towards a most interesting book published a few years later by the same lady after her marriage with the well-know botanist Mettenius, and containing a complete biography of her father, containing also many particulars, very interesting from a purely botanical point of view ²). It seems that this beautiful book has become little known in our botanical circles, and I was very grateful to Prof. Schoute, when he directed my attention to it.

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¹) Leopoldina 13, 1877, p. 50, 66.

²) C. Mettenius, Alexander Braun's Leben nach seinem handschriftlichen Nachlass dargestellt. Berlin 1882.

Though the anatomical diagrams are not further treated here, I may point to the representation of the course of vascular bundles in the stem as given by Nägeli and Schwendener. See plate II, fig. 1. Here too the cylinder of vascular bundles has been represented as unrolled.

Nägeli and Schwendener observe that diagrams of this kind could be made with the help of two other methods [1] : 1. by making or considering the stem transparent and producing a perspective drawing of the system of vascular bundles; 2. by supposing that the vascular bundles are placed in a conical plane with a very wide base by projecting them on the basal plane of the cone. The longitudinal lines then appear as radii and the transverse sections as concentric circles.

The authors however observe that the two latter methods are preferable only for special cases, while in ordinary cases the cylinder-projection is best adapted to give a general survey.

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[1] Nägeli und Schwendener, Das Mikroskop, Leipzig 1877, p. 633.

PLATES AND THEIR EXPLANATION.

Explanation of Plate I[1]).

Fig. 1—12. Organotactical transverse floral diagrams after Eichler, Blüthendiagramme.

Fig. 1. *Cruciferae*; MM median plane; TT transverse plane. Bract and prophylls aborted and therefore drawn in dotted lines.

Fig. 2. *Gramineae*; A empirical and B theoretical diagram; the latter according to Eichler's conception [2]); b lower, v upper palea, l lodiculae.

Fig. 3. *Linaria vulgaris*, with indication of lips and of palate (dotted line) on lower lip.

Fig. 4. *Primula acaulis*; empirical diagram; 1—5: figures indicating the succession of the development of the sepals; adnation of stamens on corolla indicated.

Fig. 5. *Carex*; A male flower, B secondary female one-flowered spike: a slightly developed branch, bearing one bracteole developed into a utricle (utr) and in its axil the female flower consisting only of a pistil.

Fig. 6. *Aconitum Napellus*; p poorly developed petals.

Fig. 7. *Vicia Faba*; v vexillum; a alae; c carina.

Fig. 8. *Nymphaea alba;* bract and bracteoles typically wanting; abbc sepals.

Fig. 9. *Compositae*, tubular floret; d annular nectary at the foot of the style.

Fig. 10. *Hypericum quadrangulum*; α: first bracteole, β: second bracteole, S continuation of screw; 1—5: figures, indicating the succession of the development of the sepals.

Fig. 11. *Althaea rosea*; i: epicalyx.

Fig. 12. *Orchis*, after the resupination of the flower; l labium; o staminodes.

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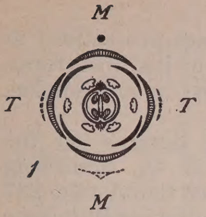
[1]) Plate I—VII are redrawn and arranged by Mr. R. Hoeksema, draughtsman to the Botanical Laboratory of the Groningen University.

[2]) There is also another explanation for the flower of *Gramineae*, but because my only purpose was the mode of drawing the diagram, I have preferred the reproduction of all figures in accordance with Eichler's work.



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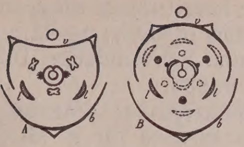
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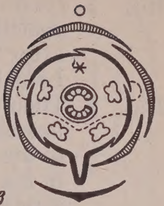

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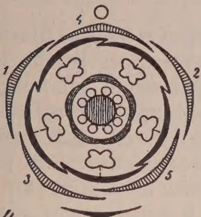

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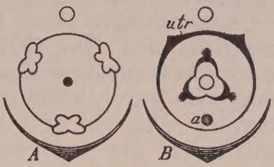

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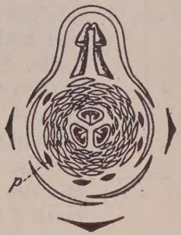

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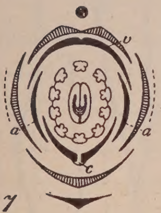

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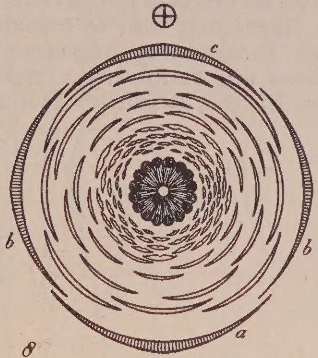

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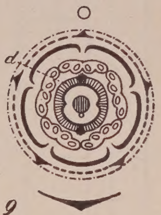

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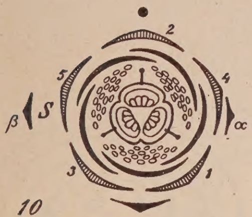

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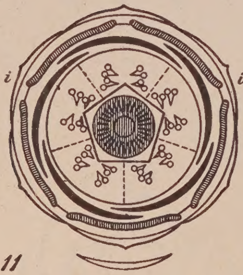

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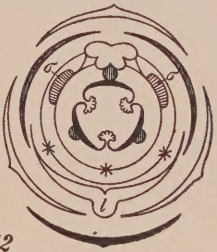

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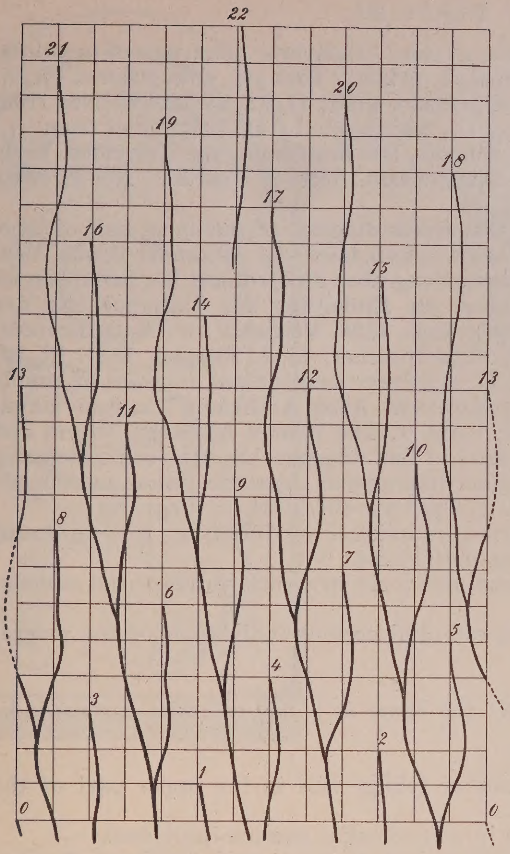
Explanation of Plate II.

Fig. 1. *Iberis amara*; longitudinal diagram (cylinder-projection) of vascular bundles in stem; 0—22, numbers of leaf insertions, after Nägeli und Schwendener, Das Mikroskop, 2nd edition, Leipzig 1877, p. 636.

Fig. 2. Theoretical longitudinal diagram of the designs on the unrolled stem surface for a phyllotaxy of $^2/_5$, according to the theoretical views of G. v. Iterson, to be found on p. 237 in his work: Mathematische und mikroskopisch-anatomische Studien über Blattstellungen nebst Betrachtungen über den Schalenbau der Miliolinen. Jena 1907.

Fig. 3. *Castanea vulgaris*; A. transverse diagram of a lateral distichous leafy shoot, with purely male inflorescences in the leaf axils. B. transverse diagram of a lateral shoot showing a quincuncial phyllotaxy and male and polygamous inflorescences, the stipules of the foliage leaves (3—12) being omitted. If we do not take into account scale leaves and prophylls, this figure may also be considered as a diagram of the top shoot. C. transverse diagram of a male flower glomerule; stamens and rudimentary pistil drawn only in the main flower. Eichler, Blüthendiagramme, Vol. II, p. 21.



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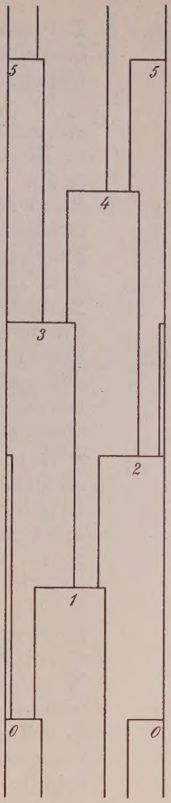

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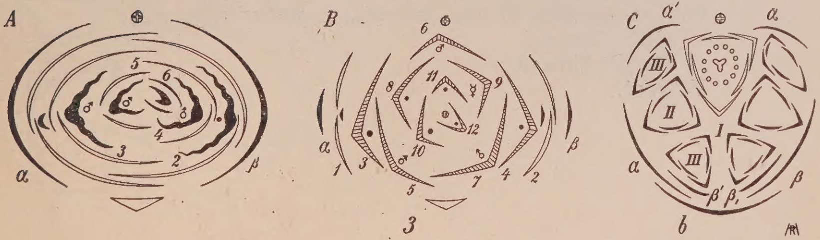
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Explanation of Plate III.

Fig. 1. *Triticum, Secale, Avena*; transverse diagram of seedling. Scutellum hatched; 1, primary stem; $^1/_1$ coleoptilum; $^2/_1$, $^3/_1$, foliage leaves of primary stem; 11, 12, 13, lateral buds from $^1/_1$, $^2/_1$, $^3/_1$; $^1/_{11}$, $^2/_{11}$ leaves of 11; 111 lateral bud from $^1/_{11}$, etc. After J. C. Schoute, Die Bestockung des Getreides. Verh. d. Kon. Akad. Amsterdam. Sect. 2. Vol. XV. No. 2. 1910, p. 16.

Fig. 2. *Pinus strobus*; transverse diagram of the upper half of cone, looked at from below; phyllotaxy $^5/_{13}$. Alexander Braun, Vergleichende Untersuchung über die Ordnung der Schuppen an den Tannenzapfen, als Einleitung zur Untersuchung der Blattstellung überhaupt. 1830. Verhandl. der Kais. Leopold. Carol Akad. d. Naturforscher. 15, I, Breslau, 1831, Pl. 24.

Fig. 3. *Euphorbia* e.g. *E. segetalis*; longitudinal diagram of simple alternation of generations. After Al. Braun, Das Individuum Berlin 1853, p^l. V fig. 1. The Roman numerals, letters and other symbols used in this diagram have the same meaning as in the analogous diagrams of the same author reproduced on Plate IV—VII. They are for all these diagrams:

I. primary cormus-individual of the first generation of essential cormus-individuals.

II, III, etc. second, third, etc. generation of essential cormus-individuals.

I^1, II^1, etc. non-essential cormus-individuals of the several generations.

C cotyledon.

N cataphyll. N^1 the same in a non-essential cormus-individual.

L foliage leaf.

l somewhat reduced foliage leaf in the upper part of the middle region.

L^1, l^1 the same in non-essential cormus-individuals.

L*, L**, etc. foliage leaf of the second, third, etc. annual shoot.

H bract.

h bract of a second kind, like bracteoles, etc.

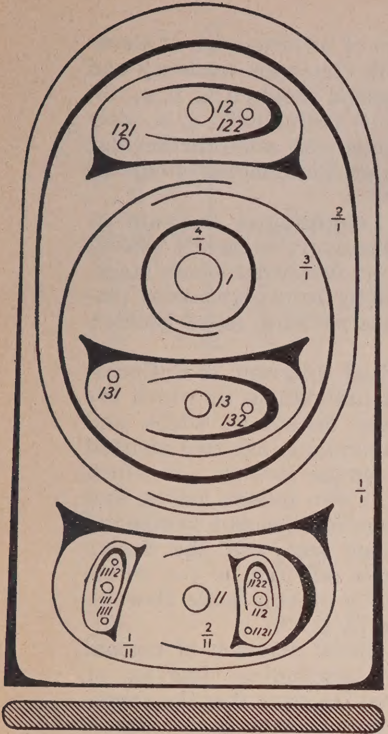
H1, h1 bracts in non-essential cormus-individuals.

Z hermaphrodite flower. Z1, Z2, etc. the same in first, second, etc. grades of non-essential ramification.

♂ male flower.

♀ female flower.

W root.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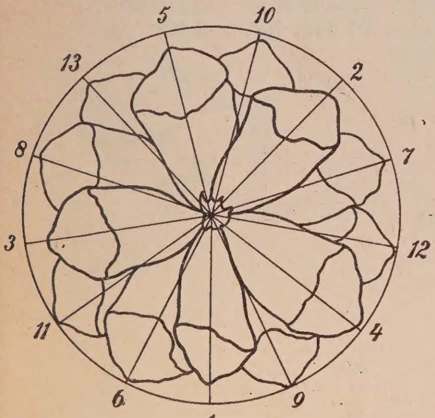

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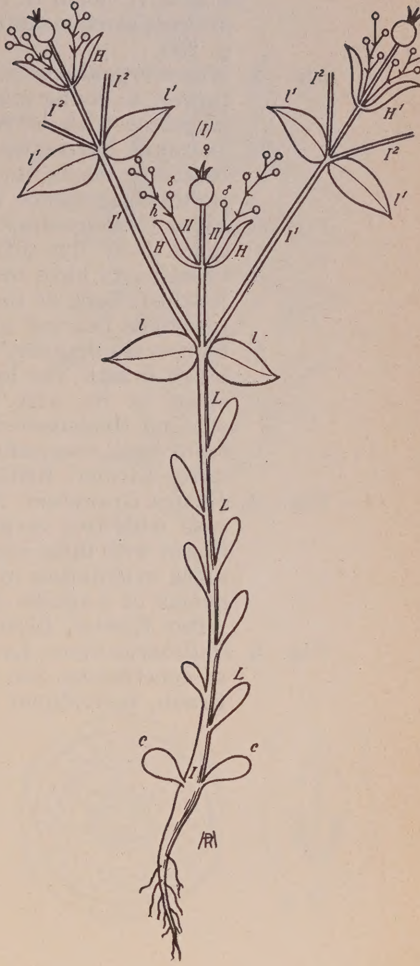
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Explanation of Plate IV.

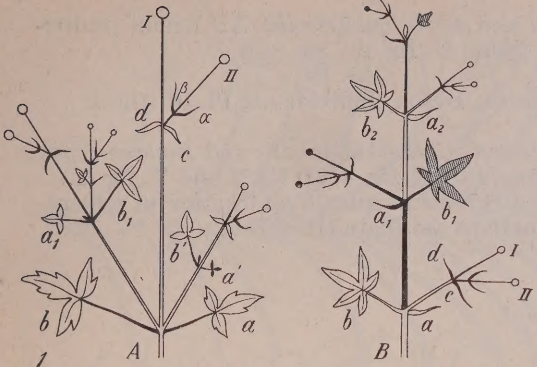
Fig. 1. *Geranium.* A: longitudinal diagram of inflorescence of *Geranium Robertianum*; dichasium with cincinnus-tendency and furthering of the shoot from the second prophyll; a, b, a_1, b_1, α, β prophylls of succeeding cormus-individuals; c, d scaly bracts. B: do. of *G. roseum*, cincinnus with same furthering; symbols same meaning. After Eichler, Blüthendiagramme II, p. 293.

Fig. 2. *Mesembryanthemum violaceum.* Longitudinal diagram of flower. a: young stage in which the ovary is hardly closed; placentae with normal position; b: somewhat older stage, placentae horizontal; c: stage shortly before anthesis; placentae by displacement more or less parietal. After Eichler, Blüthendiagramme II, p. 123.

Fig. 3. *Emex Centropodium.* A: longitudinal diagram of inflorescence. I—V five different cormus-individuals, of which the basal parts have been alternatively drawn in white and hatched. Each of these cormus-individuals has two aborted prophylls bearing glomerules of female flowers (of which transverse diagram in B), three or two foliage leaves, and a few bracts. The lowermost foliage leaf bears a sympodial shoot in its axil, the last foliage leaf and the bracts subtend condensed dichasia of male and female (of which transverse diagram in C) or finally of only male flowers. After Eichler, Blüthendiagramme II, p. 76.

Fig. 4. *Punica Granatum.* A: transverse floral diagram of normal case with two carpid whorls. B: longitudinal diagram of flower with three carpid whorls, making clear that the anomalous orientation of the outer whorl carpids is the consequence of a similar displacement as in *Mesembryanthemum.* After Eichler, Blüthendiagramme II, p. 489.

Fig. 5. *Helleborus niger.* Longitudinal diagram of simple alternation of generations. See for explanation Pl. III, fig. 3. After Al. Braun, Individuum, Plate I, fig. 2.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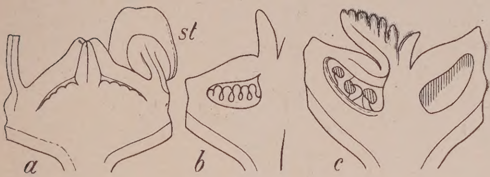
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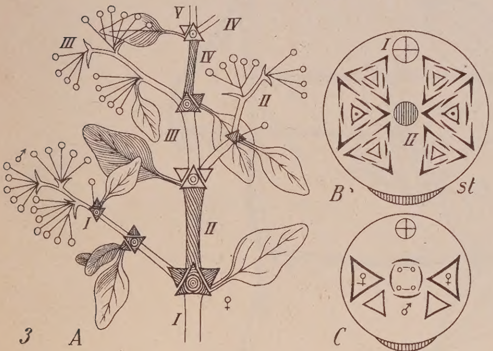
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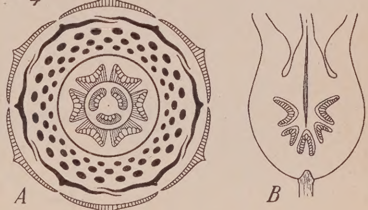
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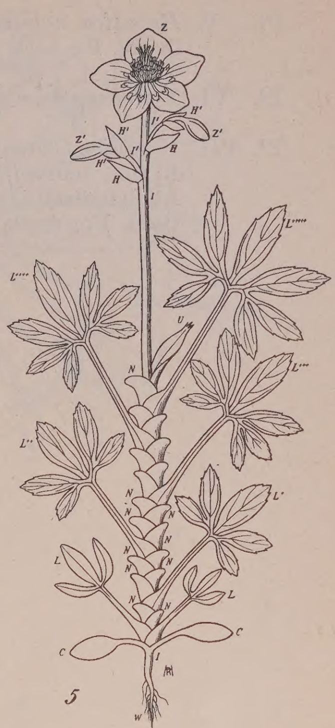
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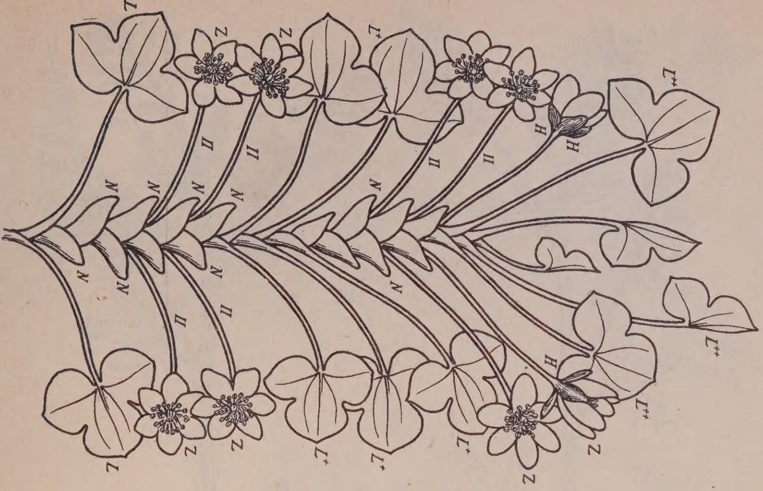
Explanation of Plates V—VII.

Pl. V. *Hepatica nobilis* and *Paris quadrifolia.* Al. Braun. Individuum, Pl. I, fig. 3 and II, fig. 2.

Pl. VI. *Trifolium montanum,* Braun, Individuum, Pl. IV, fig. 1.

Pl. VII. *Veronica Chamaedrys, Galanthus nivalis* and *Juglans regia,* Braun, Individuum, Pl. III, fig. 4, II, fig. 4 and V, fig. 3. All longitudinal diagrams of simple alternation of generations. For explanations see Plate III, fig. 3.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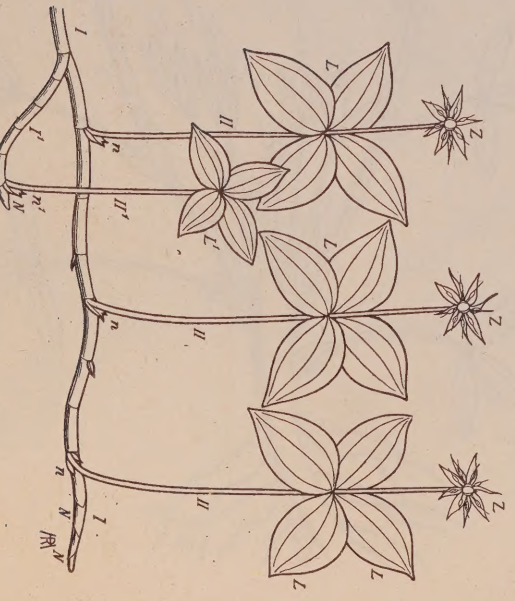
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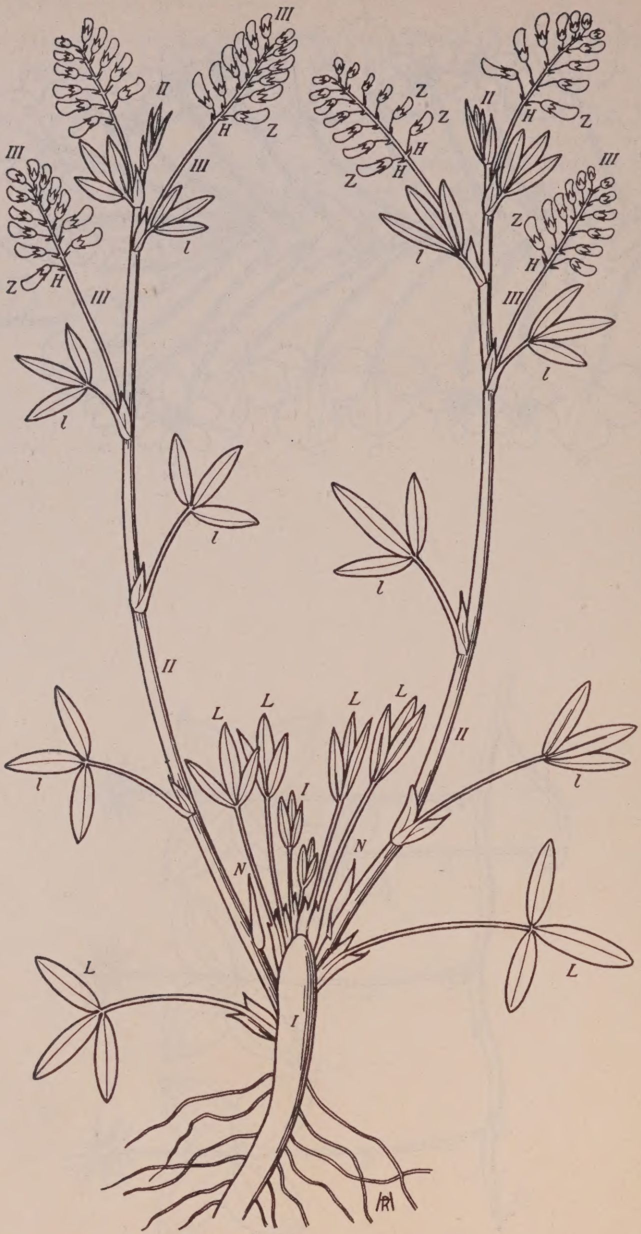
Pl. VI.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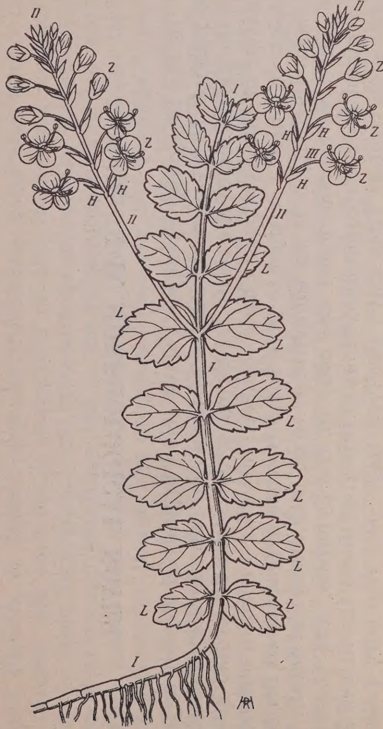
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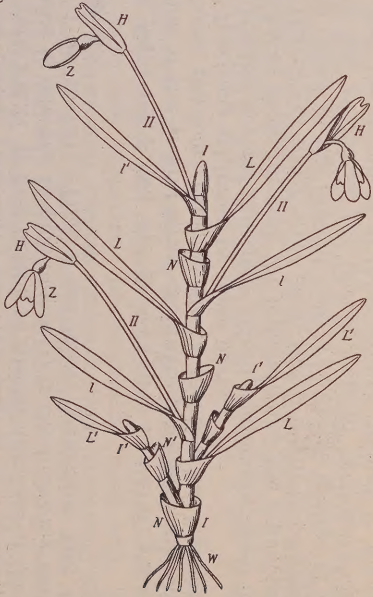
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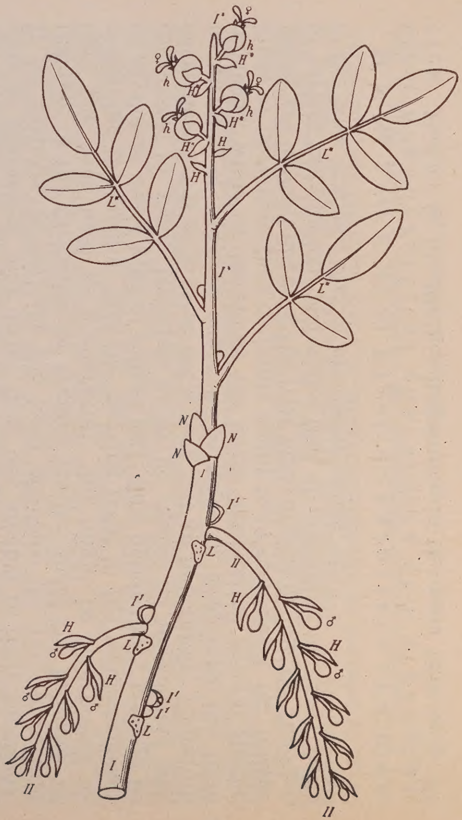
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DIVISION II. MORPHOLOGICAL NOTES.

In the foregoing Synopsis I have tried to restrict myself as much as possible to the communication of facts and considerations essential to the definition of the technical terms, which form the proper subject matter of this Synopsis. There occurred however a certain number of cases, in which I wished to give some further explanations for more special elucidation of my thoughts or to go into historical detail. This would have overburdened the body of the Synopsis, and therefore, I brought together communications of this kind under the title of Morphological Notes. They have received their own numbers preceded by the letters M.N. If they belong to special numbers of the Synopsis, the reader is referred to such numbers, in the following manner: (cf. S. No. 1 up to 751). Thus a sufficient connection may have been established.

M. N. No. 1 (cf. S. No. 5). Division into organs. In the definition of the several terms designating the principal organs such as thallome, phyllome, caulome, etc. no mention has been made of the several functions exhibited by these parts.

Nevertheless several functions afford characters based on facts as undeniable as those forming the foundation of the organotactical and plastic characters which were used. But it ought to be kept in mind, that the object in the present case is to define groups of organs all more or less exhibiting the phenomenon of metamorphosis, which means that the members of those groups, though in many respects alike in characters, may differ from one another in their functions. If for instance in defining the term phyllome the very important function of the formation of organic matter under the influence of light had been used as a character, this might be interpreted as sustaining the opinion that the starting point in the metamorphosis of phyllomes was a kind of foliage leaf. This opinion may perhaps be considered by many botanists as by no means an improbable one, nevertheless it is at present not a fact, but an hypothesis. Therefore no mention of function ought to be made in describing the term phyllome, while in describing the terms designating several special kinds of phyllomes they certainly ought to be mentioned, for foliage leaves are without doubt in the first place organs having the function of carbon assimilation, bud-scales that of protecting the inner parts of the buds, stamens that of producing pollen, etc.

M. N. No. 2. (cf. S. No. 5). Plastic characters and plastics; organotactical characters and organotactics. Eichler in his Blüthendiagramme in the year 1878 on p. 74

of the second part mentions that he will use the term plastics (in German Plastik, in Dutch plastiek), following Alexander Braun in this respect, for indicating characters of the flower not so much related to their diagrammatical structure as concerning the external differentiation and functions and in the subsequent half of his work he often makes use of this expression. I have been unable to find where Alexander Braun has proposed this term, but perhaps it was only in his lectures. Anyhow not only Eichler, but also Velenovsky in his Vergleichende Morphologie and others, for instance several authors in Das Pflanzenreich, etc. use it with a certain predilection. Therefore it seems to me that the terms plastic characters and plastics deserve to be used as in the Synopsis.

On the other hand the term "Morphological characters" is often used to indicate those characters to which a special importance is attributed in classifying systematic Botany. It is however obvious that in General Morphology, as the meaning of this term has been explained in S. No. 1, all characters whatever may be called morphological, so that there is no reason for limiting the use of this term to indicate only a group of characters chiefly of a numerical and spatial kind. Therefore in the synopsis another terminology has been introduced. The term organotactical characters has been chosen for such as are chiefly of numerical, spatial and systematical importance, whilst the term organotactics is used for the assemblage of such characters.

M. N. No. 3. (cf. S. No. 6). Analogous and homologous organs; analogy and homology. By a careful study of this interesting subject I have come to the result that the definitions, by which these terms are commonly characterized, are neither practical nor indeed well-founded from a more theoretical point of view. It seems to me that the definitions given in S. No. 6 are in every respect more apt and in this Note I will try to bring the reader to the same conclusion. For this purpose it will be necessary to consider in the first place their use in Zoology and afterwards that in Botany, for though they are used also in the latter discipline, they nevertheless appear much more frequently in descriptions of animal objects. Moreover botanists have in general used these terms in the sense which they had received in Zoology. We will therefore consult in the first place some leading manuals of animal morphology, comparative anatomy and comparative embryology.

In doing this we find that the following examples are produced for illustrating those terms.

The gills of fishes and the lungs of mammals are analogous organs, but the swimmingbladder of fishes and the lungs of mammals are homologous [1]). Gegenbaur [2]) brings forward the gills of fishes and those of lobsters as analogous organs. A truly classical example often used in lectures is that of the wings of birds and the wings of butterflies as analogous in contrast to the wings of birds and the forelimbs of mammals or the arms of men as homologous organs. It will draw the reader's attention that in all these examples a comparison is made between organs belonging to two different species, but this feature is by no means essential. For every biologist will consider the arms and legs of men as homologous organs and there are many, who even consider right and left arm of the same body as homologous [1]. Keeping this in mind and then starting from these examples it would seem simple and evident to come to the following definitions, which are indeed those used in the Synopsis: analogous organs = organs having the same plastic, but different organotactical characters, against: homologous organs = organs having different plastic, but the same organotactical characters. These terms would thus indicate an interesting contrast of characters between two peculiar classes of organs, existing beside much larger classes, which are in these respects wholly of the same kind, exhibiting the same plastic and the same organotactical characters, like the feet of a myriapod. In this sense analogous organs are rare, homologous much more common.

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[1]) E. Haeckel. Generelle Morphologie der Organismen I, Berlin 1866, p. 314, footnote.

[2]) Gegenbaur. Vergleich. Anat. d. Wirbelth. I, 1898, p. 22.

When we however consult some of the principal text-books of zoological morphology, not with the object of finding examples but in order to ascertain the precise sense attached by their authors to the terms analogy and homology, we find that the prognosis mentioned above by no means comes true. Haeckel in his Generelle Morphologie I, p. 312 ss. gives some historical data and mentions the opinions of Bronn and Owen. Haeckel himself calls analogy a physiological comparison (physiologische Vergleichung) and homology a morphological comparison (morphologische Vergleichung), meaning thereby that all organs having the same "morphological" characters are homologous. Moreover in accordance with Owen he is of opinion that homology is a comparison between two or more corresponding parts belonging to two or more different organisms. By Gegenbaur analogy is called physiological similarity (physiologische Gleichartigkeit) as compared with homology as morphological similarity (morphologische Gleichartigkeit) and he draws from his definition the same inference as Haeckel.

Oscar Hertwig [2] gives a wider definition of the term homology, which however agrees substantially with those mentioned above. He says: "Organs which in structure and composition, in disposition and arrangement and their relation to other neighbouring organs up to a certain degree, agree with one another and hence mostly also exhibit the same function and use in the organism, are indicated in comparative anatomy as homologous to one another".

It is clear that the conceptions of these various authors do not exactly correspond to the examples mentioned above. They are not confined to the cases mentioned in those examples but bear a more general and ostensibly a more theoretical character. The reader has already seen that according to them, homologous organs are not only those with the same organotactical, and different plastic characters, but also all organs with the same organotactical and plastic origin, viz. all organs which are of the same kind in both respects. The latter group comprises the great majority of homologous organs and all members of this group may at the same time be termed analogous organs if only they are not considered from an organotactical but from a functional point of view. It may be further mentioned here that some authors on animal morphology define homology as a consequence of relationship, and thus bring into morphology a hypothetical element which never can be used as one of its foundations. Referring the reader to what has been said on this subject in the first article of the Synopsis, it will be superfluous to refute here opinions of this kind [1].

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[1] Darwin. Descent of Man, 1875, p. 43 and Animals and Plants under domestication II, 1888, p. 314.

[2] Handbuch d. Entwickelungslehre d. Wirbelthieren, 1906, Bd. III, Teil 3, p. 151.

On the other hand some criticism of the views which were cited more in detail, is needed. I mentioned above that according to Haeckel and Owen, it is necessary for the existence of homology that the organs which are compared together should belong to two or more different organisms, thus the wing of a bird may be considered as homologous with the hindleg of a mammal but not with the leg of the bird itself. Such a consequence is however clearly in contradiction with the definitions themselves. It therefore seems but natural that Gegenbauer and Hertwig have not adopted this view. But even in its simpler form the conception of homologous organs, restricted to such as have the same organotactical characters, seems not to offer an example of efficient terminology, but rather of the effect of a certain love of generalization which however in this case is misplaced. In the first place the contrast between analogy and homology which was apparent in the examples cited above has been lost in the definition of the term "homologous". This is probably due to the fact that the term analogous organs is relatively seldom used in animal morphology, whilst the study of homologous organs is one of its principal objects. This loss is regrettable, because the two groups of organs contrasting in their organotactical and plastic characters are highly interesting ones and sooner or later it might become necessary to invent a new term for designating them. In the second place, and this is a more important objection, the term homology as it is now commonly used in animal morphology is not a result of a proper analysis of the facts with which we are concerned here and this has given rise to a terminology in which the greater number of the cases to be distinguished belongs to both categories, for we have seen that all organs having the same organotactical as well as plastic characters must be considered both as analogous and homologous. It seems probable that the diffuseness of this terminology has been caused by the fact that in morphological descriptions there were needed certain

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[1] See also Oscar Hertwig, l.c. p. 179.

terms for indicating the disposition and arrangement of organs having the same organotactical origin, combined either with the same or with different functions. Such terms for vertebrates are: homotypical organs, like right and left eye, homodynamical organs, like vertebrae of the segments of arthropoda, homonomical organs, like fingers and toes of the higher vertebrata, etc. [1]) But it is evident that these terms only refer to the reciprocal positions and arrangement of organs having the same organotactical value, but not at all to the contrasts which may exist in such groups between organotactical origin and function. I think that it would be possible to meet the objections mentioned here by simply limiting the use of the terms analogy and homology to those cases in which an antagonism between organotactical and plastic characters exists, and further by not subordinating homodynamical or homotypical organs and the like under the group of homologous organs, but by uniting them into another independent group consisting of organs with the same organotactical characters, without regard to the question whether their plastic characters are the same or different. The subdivisions homodynamical etc. would then be distinguished with respect to reciprocal arrangement. But with my limited knowledge of animal morphology I am incompetent to make such a proposition. Correctness is certainly wanted in the first place in terminology, but a certain continuity is needed as well, and I cannot decide to which of the two precedence belongs in this case.

Now turning to vegetable morphology it ought to be kept in mind that plants do not, like many animals, exhibit a contrast between trunk and extremities. The vegetable body shows another type of symmetry and repeated ramifications play an important part. Thus there has never existed a temptation to combine with the term homology other terms designating the arrangement of certain organs. Cyclic and spiral arrangement, ortho- and parastichies, whorls, alternation and superposition, haplo- up to polycaulescent stems, sympodia, etc. are terms used in a general way for describing arrangements of organs, apart from their organotactical and plastic characters. Hence in Botany it seems that the question about the difference between the terms analogy and homology remains as a simpler problem. Consulting botanical literature we nevertheless find that several opinions existing in animal morphology are reproduced here.

I will now first give a short survey of some opinions entertained by well-known botanists or to be found in some of the large works on vegetable morphology. We will thus collect the necessary material for forming a definitive opinion.

Strasburger's [2]) conception of the terms homology and analogy exhibits a very theoretical character and is based upon his ideas concerning evolution, adaptation, etc. He distinguishes an architypical and a phytotypical homology and a special kind of analogy which he calls phytotypical also, but he does not give us clear definitions of the terms homology and analogy themselves. Referring the reader further to the critical remarks made above I do not think that his exposition of the matter can afford a solid basis for further discussion. In his text-book [1]) he distinguishes as homologous: "such parts which it is reasonable to presume have had a common origin" and as analogous: "those which, whilst probably having different origins, yet exercise the same function". It is clear that here in the case of homologous organs it is deemed of no importance whether they have the same or different functions.

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[1]) Gegenbaur, l.c. p. 23.

[2]) E. Strasburger, Ein Beitrag zur Kenntniss von Ceratophyllum submersum, Pringsheim's Jahrb. 1902. Bd. 37. p. 523.

Velenovsky [2]) calls analogous organs such organs which are "a faithful imitation of one another, notwithstanding their having a wholly different morphological value". Homologous organs are called by him "organs belonging to two different species of plants showing the same relation to the whole body in the same generation, independent of function and external shape." When he requires that homologous organs should belong to two species he follows Haeckel in his mistake which was already signalized above. Here it would mean that e.g. though petals of *Papaver* and foliage leaves of *Rosa* are homologous organs, the same could not be said of the petals of *Papaver* and its own foliage leaves. For the rest Velenovsky considers organs having the same organotactical and plastic characters as homologous.

Kirchner, Loew and Schröter [3]) give the following definitions of the term analogous organs: "organs of similar shape and function in different systematical groups owing their similarity not to their phylogenetic correlation but to the same adaptation (e.g. succulent stems of *Euphorbiaceae* and *Cactaceae*)". This definition certainly has a very hypothetical foundation and is moreover erroneous, for in the cases mentioned by the authors there is no question of any contrast between organotactical and plastic characters, but simply of a difference between the systematical groups to which the several organs belong. Such groups of organs are called in oecology parallel adaptations. In homology the authors distinguish three different kinds. Two of these are united into a group characterized by the same definition which was given above for analogous organs (!) and are called: 1. phylogenetic homology (monophyletic), e.g. microsporangium and pollensac; 2. homology of organisation (polyphyletic), e.g. leaves of *Hepaticae*. The third kind is formed by organs of the same plant different in function but the same in origin and position, e.g. foliage leaf and stamen. I think that elaborate critical remarks are superfluous here.

Goebel [4]) in one passage (p. 108) identifies homology with morphological significance. In another passage (p. 313) he says: "One of the most fundamental principles of morphology is that the external appearance and correlated function of an organ decides nothing about its morphological significance, or in other words that the same function may be exercised by organs of different morphological significance, that we must distinguish between analogous and homologous organs." The tendrils of *Vitis* and *Passiflora* against those of *Papilionaceae* are given as an example of analogy. In a letter dated Febr. 13th. 1924 Prof. Goebel writes to me: "The expression on p. 313 of the second edition of "die Organographie der Pflanzen" means in fact that which you infer from it: analogy the same function and different morphological significance; homology the same morphological significance and different function." 1)

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[1]) A text-book of botany by Dr. E. Strasburger, Dr. H. Schenck, Dr. F. Noll and Dr. G. Karsten, 3rd eng. ed., 1908.

[2]) Vergleichende Morph. d. Pflanzen, 1905, Teil I, p. 25.

[3]) Lebensgeschichte d. Blüthenpflanzen Mitteleuropas, Stuttgart 1908. Band I, Abteilung I, p. 34 and 44.

[4]) Organographie d. Pflanzen, Aufl. 2, Jena 1913, Teil I.

The reader will agree that in botanical literature there is a great variety of opinions, some of which are open to criticism, and there is throughout a certain want of clearness. But there are no arguments of tradition or continuity which could lead us to accept in Botany a definition, to be considered as inefficient in itself, for terms of so much importance in vegetable morphology. This being allowed I think that the reader who has followed me thus far will have no objection to follow Goebel and myself when we restrict the use of the terms analogy and homology to those cases in which we want to distinguish from one another two classes of organs showing contrasting combinations of organotactical and plastic characters and this principle has been worked out in the Synopsis.

M. N. No. 4. (cf. S. No. 12). Plant-individual. It may seem superfluous to give further explanations here concerning this subject, as it has been dealt with in the Synopsis; but many controversies about it have arisen between scientists of the very first order and therefore it is worth while to give here some historical and critical remarks. I refer the reader who is interested in this subject to some opinions cited below dealing especially with the botanical side of the problem. 2)

Spring (1838) distinguished a physiological individual represented by the whole metamorphosis and a systematical one represented only by a single phase of development. It does not seem necessary expressly to demonstrate that so purely theoretical a conception of the term cannot be of any use in modern phytography.

Several other opinions with a better foundation on facts have been

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1) Kirchner c.s. mention that their definition of homology which was cited above, has originally been given by Goebel. In the same letter Prof. Goebel declares that this must be a mistake and that the only passages concerning analogy and homology which were written by him are those in his "Organographie" cited in the text.

2) Aug-Pyr. de Candolle, Physiologie végétale, tome 2, Paris 1832, p. 957.
A. Braun, Das Pflanzenindividuum der Pflanze. Akad. Berlin 1853.
G. Th. Fechner, Ueber die Seelenfrage, Leipzig 1861.
L. Errera. L'individu, 1902, Rec. d'oeuvres Bruxelles 1908—1910, Tome Physiol. gén, Philosophie 1910, p. 129.

brought forward and I think that they belong to two categories. The first of these is based on the supposition that the principal attribute of an individual is always sexual reproduction. This is obviously a mistake, probably originating from the fact that speaking of individuals it seems to be unavoidable to think in the first place of the human individual; and in this case sexual reproduction is indeed a very interesting and important character, though by no means one of the first order. But this mistake leads to very bad consequences. The occurrence of individuals is thus denied to all living beings exhibiting only vegetative reproduction, like *Bacteria* and *Cyanophyceae;* and a still stronger objection is, that in cases where sexual and asexual reproduction are both possible, we are forced to consider a large number of beings leading a perfectly separate life as representing all together a single individual. Thus Huxley supposed that the whole asexual summer generation of plantlice, amounting in some cases to a trillion, together with all male individuals asexually produced, were the representation of only a single individual by successive, coexisting and separable forms! In Botany the opinion has often been held that plants reproduced by means of cuttings or grafts in any number may represent a single individual and in this respect the example of *Salix babylonica* has often been cited. De Candolle in 1832 already objected to the notion that the trees of *S. babylonica* decorating the tombs of Napoleon at St. Helena and Rousseau at Ermenonville should together represent only a single individual. This conception of individuality is indeed a very strange one, for it is evident that for reproduction-individuals independence of other individuals, the leading of a separate life, a well-defined beginning and end, and a certain measure of indivisibility are far more important characters than sexual reproduction, and that the neglect of this truth must lead to an arbitrary and unnatural conclusion. Nevertheless not only Huxley, but a considerable number of prominent and even illustrious authors have adopted it, among them Aristotle, Hippocrates, Goethe, Erasmus, Darwin and Linné, but as regards the last named it must be kept in mind that sexuality of plants in his time was a new and most important discovery, on which he founded his celebrated sexual system. It may be said however that the above conception of individuality has been abandoned by most botanists, as is proved by the fact that the term "clone" has been introduced for designating a group of individuals all descended by means of vegetative reproduction from a single individual, such as the European representatives of *Salix babylonica* and many races of cultivated plants, for instance *Saccharum officinarum, Beta, Hevea,* etc.

The second category of opinions contains a great variety of views which nevertheless are all bound together by the supposition, that the several groups distinguished in systematical Botany exhibit without exception homogeneous individualization and are composed only of a single kind of complete individuals. This however is again a mistake, as has been set forth in the synopsis. Paracelsus saw the difficulty in the case of mankind and tried to solve it by the assumption that husband and wife together constituted only a single individual, thus applying the same method which was afterwards used much more extensively in cases like those of plantlice and *Salix babylonica*. In Botany however no corrections of this kind have been applied and all authors who have written on the subject of the plant-individual simply start from the view that every systematical group like a species or variety must needs be homogeneous. It is true that the existence of alternation of generations, with a gametophyte and a sporophyte, was not at all or imperfectly known to many of them, though on the other hand the existence of dioecious plants was known to all. I am unable to trace the psychological causes of the phenomenon, but it is a fact that this strange mistake has led many authors to seek for a single phase in the developmental cycle of plants, which might be considered as fully representing the species. It is further a curious fact that most authors have been satisfied when they thought they had found the unit fit for representing the higher plants, and completely lost view of the lower groups, though among those authors there are several who possessed a thorough knowledge of the latter. It is evident that the consequence of such a proceeding often must have been the promotion of some subordinate or organ-individual to the rank of plant-individual, and in a few cases even non-living parts of the plant have been pressed into service. The following were considered as the true plant-individual: the cormus-individual, dealt with in S. No. 242 of the synopsis (shoot or Sprosz of Alexander Braun), the phyton, being an internode with its leaf or whorl of leaves and a hypothetical root (Gaudichaud 1841); the anaphyte, being a member which when separated from the plant can lead an independent life and develop into a complete plant (Schultz, die Anaphytose 1843), a vague term, because so many parts of plants are capable of such a development and many lower as well as higher plants can be vegetatively reproduced by a single cell only, such as *Mosses, Begonia,* etc. Further the cell; plastids; Starch-grains; corpuscles exhibiting Brownian movement.

M. N. No. 5. (cf. S. No. 16). Habit. On this subject I have treated at some length in my preface to the work entitled Botanical Pen-portraits (1923, p. 3). I refer the reader to those remarks, but nevertheless it may be well to mention here that the term habit is in fact used in two senses. It is often defined as the knowledge of the general aspect of plants, meaning thereby the herbaceous or woody character, shrubs or trees, the mode of branching and the several directions and sizes of the branches [1]), the erect, climbing etc. character of the stem. Indeed Hooker [2]) when he describes habit as consisting of characters striking the eye at first sight such as size, colour, ramification, arrangement of the leaves, inflorescence, etc., uses the term in the same sense.

But I cannot see how such a term can be of real use, comprising a not strictly defined complex of generally known and simple characters which themselves may be described with the help of a well defined and generally known terminology.

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[1]) Hofmeister. Alg. Morphol. p. 428.

[2]) Flora of British India, Vol. I 1875, p. XXIV, 183.

On the other hand the term habit is often used by botanists in another sense, standing for a complex of characters, neither analysed nor described in words, and more or less intuitively known, the knowledge of which is however sufficient for instant and exact identification and determination.

I think that taken in this sense the term habit is much more useful and accordingly it has been used so in the Synopsis.

Though the more or less intuitive knowledge of habit is often most efficient in scientific work, yet there are cases in which no differences of habit are to be detected by keen observers and where nevertheless an exact description brings to light very real differences. An example of this kind is to be found in a publication of Mr. S. A. Arendsen Hein [1]). Experimenting with some well defined species and varieties of the genus *Tenebrio* he found that their larvae were not to be distinguished from one another by mere habit. He then made pen-portraits of them and thus was able to find a sufficient number of distinctive characters for identification and determination of all the larvae. The above particulars were not mentioned in Mr. Arendsen Hein's paper, but were communicated by him in letters written to Miss T. Tammes and afterwards to myself. (June 22, 1923).

M. N. No. 6. (cf. S. No. 20). Metamorphoses. In the conception of general morphology which forms the basis of the Synopsis it is but natural that the notion of the existence of a fundamental form which has been metamorphosed into various other forms has not been admitted in the definition of the term metamorphosis. In the present state of science evolutionists will certainly take for granted that e.g. the several kinds of phyllomes have been developed in course of time from one or a few fundamental forms, and the type of the foliage leaf will perhaps in this respect attract their attention in the first place, but it is evident that such a view can only be maintained on grounds perhaps more or less probable but yet of a hypothetical character. In general morphology however, our opinions and terms ought to be based as much as possible on indisputable facts and I think that this has been accomplished in the definition of the term metamorphosis in the Synopsis.

M. N. No. 7. (cf. S. No. 22). Alternation of Generations. In the conception of general morphology as it has been developed here, a terminology is needed with a simple and matter of fact character. It must be kept as much as possible free from theoretical considerations, though this is not always possible. To illustrate this problem I may give here a few examples. The first is taken from one of that large series of excellent German text-books, which without altering the face of Botany, like that of Julius Sachs did, nevertheless are of the utmost importance for the progress of science, because they bring large masses of material, most useful for investigators and not attainable in any other way. As the prototype of such works we may consider de Bary's Vergleichende Anatomie der Vegetationsorgane, after more than fifty years still the trusty guide in anatomical researches. An important work of a similar kind is Oltmans, Morphologie und Biologie der Algen; and in his second edition 1923, vol. 3 on p. 137 there occurs an interesting discussion entitled Generations- und Phasenwechsel. It is a review of the phenomenon of alternation of generations throughout the vegetable kingdom, in its relation to the reduction division of the cell nucleus. It starts from the theoretical conception that alternation of generations is a phenomenon of almost universal occurrence and that in some cases where it is wanting, it is probable that it has disappeared in the course of evolution. It cannot be denied that this hypothesis is in some respects well founded, but its introduction into terminology may have a detrimental effect.

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[1]) Larvenarten von der Gattung Tenebrio und ihre Kultur. Entomologische Mitteilungen. Band XII, 1923, p. 127.

Though in the developmental cycle of *Fucus* no traces of an alternation of generations appear, the author considers its body as a diploid sporophyte, not being inclined to accept the alternative that it might be a diploid gametophyte. He further calls the oogonia megasporangia and the antheridia microsporangia, though they produce not spores but eggs and spermatozoids (p. 144). It seems to me that the problem would be much simplified by supposing that in this case no sporophyte or micro- and megasporangia may be distinguished and that an alternation of generations is wholly wanting. In accepting the view of Oltmans the terms sporophyte and gametophyte, micro- and megasporangia and gametangia are at once deprived of their proper meanings, for it obliges us to admit the existence of sporophytes without spores and sporangia, and gametes forming the contents of sporangia. I cannot see that we ought to permit theoretical considerations to undermine the definitions of simple and much used morphological terms to such an extent, and all this only because it is wished to make our descriptions more complete by mentioning things which in reality are absent.

There are other cases however in which it is preferable to admit into terminology some theoretical considerations, where the phenomena of apogamy or parthenogenesis interfere with the normal sexual functions. Thus in describing the flowers of *Taraxacum officinale* every botanist will use the terms stamens, pistil, ovule, etc., though he knows very well that no fertilization ever takes place, and that on the other hand the function of fertilization is a character of the highest importance in the definition of all those terms. If botanists were convinced that all these organs in *Taraxacum* had nothing whatever to do with fertilization and that their similarity with sexual organs was the consequence of mere chance, they would no doubt have invented for such cases a particular set of terms. But botanists generally assume, that during the evolution of *Taraxacum* fertilization has disappeared and therefore the same terms as in normal cases are used. This is quite right, notwithstanding a certain amount of hypothesis is introduced here into the description. Here we follow the rule that in special cases it is permitted to use certain terms, though even the most important characters in the definition of those terms should be totally absent.

An example of the same kind is afforded by the term ascus. In the Synopsis there is mentioned in No. 128 and 130 as a principal character in the definition of the terms asci and ascospores, that they are developed from ascogonia. Now it is well-known that in very many *Ascomycetes* no ascogonia appear and that apogamy in this group is of frequent occurrence. Nevertheless I think that it is preferable to consider as the prototype the ascus developed from an ascogone, though of course in phytography the term ascus will be used in many cases, in which other important characters of the ascus are present, but the fundamental one may be wanting. But here also there is some theory introduced into terminology, for it is assumed that where no ascogone appears, it has been lost in the course of evolution.

And again, if we use promiscuously the terms pollen and microspores or embryosac and megaspores some hypothetical elements are mixed up with our terminology. I think that the above remarks justify the following conclusion. It is certainly of the utmost importance to use if possible, only terms in general morphology which may be completely defined by mentioning characters based on simple observations of facts, and that we must try to exclude characters based on theoretical considerations. But this is not always possible without neglecting the most important results of comparative morphology in its widest sense, and it is a fact that many useful terms have been generally adopted in Botany in which more or less hypothetical considerations play a certain part. In my Synopsis I have tried to restrict such cases and to admit theoretical characters in the definitions only when terms are much used in Botany and would lose a considerable part of their meaning by the omission. In the anatomical part of the synopsis I have succeeded in the great majority of cases in excluding characters bearing on the functions of the organs; in organography it was impossible to do this to the same extent, but the functions which were here introduced into terminology are those exhibiting a not very hypothetical character, like nutrition and reproduction.

M. N. No. 8. (cf. S. No. 28). Symmetry. In his Lectures on the principles of symmetry (1 ed. p. 3) Jaeger expresses his opinion that "the principle of form-symmetry in its strict formulation has been neglected too long already in the morphological and systematical description of the biological sciences; or at least: its scanty applications have been too rudimentary and insufficient in almost all cases. In this respect it is most necessary that the obsolete and unwieldy definitions of forms still in vogue in these sciences, should be finally abandoned for a rational system of description in which the doctrine of symmetry is the trustworthy guide".

This judgment though painted in somewhat vivid colours is nevertheless not wholly unwarrantable. If we say with Strasburger [1]) that a shoot with leaves alternately arranged must be considered as exhibiting bilateral symmetry, or with Goebel [2]) that a shoot of *Rochea falcata* is bilateral, this certainly is not in conformity with the principles of symmetry and not a correct use of the term bilateral symmetry.

Nevertheless it is very well possible with the help of small corrections to define the terms generally used in Botany so that existing contradictions with the principles of symmetry now generally adopted become harmless.

Jaeger suggests abandoning the terminology of symmetry used in Botany and to replace it by a more rational system of description. I cannot go so far, because in describing for instance a dorsiventral flower, like that of *Lamium* or *Viola,* according to mathematical principles it is necessary to adopt an axis, perpendicular to the longitudinal axis of the floral receptacle or the pedicel of the flower, an assumption, which in phytography can never make superfluous the use of the longitudinal axis of flower and pedicel. Nevertheless I certainly admit, that a description of such flowers according to the principles of the mathematical theory may be considered as a welcome addition in a complete phytography, but in the present state of things it can be only considered as an addition. For a long time to come descriptions of symmetry according to the mathematical theory will remain necessary only in a few cases, and the old botanical terminology will remain indispensable. Thus the very important continuity in phytography will be preserved, whilst the objections to be brought forward against terms like dorsiventrality, actinomorphy and zygomorphy may be easily avoided. I have therefore retained in the synopsis the ordinary terms for symmetry generally used in botanical literature, but I have tried to eliminate from the meaning of these terms a few contradictions with the mathematical doctrine of symmetry, now in use in other sciences.

It is highly probable that there exists a relation of cause and effect between the crystallographical characters of the substances forming living beings and the external shapes exhibited by those beings. Of this relation very little or nothing at all is at present known to us. But it should be kept in mind that if we could wholly adapt our descriptions of the symmetry of living beings to the mathematical theory of symmetry now governing in crystallography this would probably include no decided progress of our knowledge concerning the connection between crystals and living beings mentioned above, although it might perhaps be useful for future investigations.

M. N. No. 9. (cf. S. No. 29). Ramification. This is a phenomenon of most general occurrence and importance, exhibited by thallomes, caulomes, phyllomes, roots and appendages of the surface, in other words by all kinds of plant-bodies or parts of them. It is however a fact that the inflorescences of the higher plants have by preference been used as objects for studying the several modes of ramification and the introduction of several terms has been the result of this study. Hofmeister [1]) and Sachs [2]) have already shown that it is possible and preferable to start in this matter from a more general point of view and that many terms formerly used only for inflorescences may very well be used in a more general sense. Their example has been followed in the Synopsis.

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[1]) Strasburger, etc. Text-book third Eng. edition 1908. p. 16.

[2]) K. Goebel, Organographie der Pflanzen, 2nd ed. I, 1913, p. 202.

The fact that ramification has been treated chiefly in organography, not in anatomy, and in the general introduction of the Synopsis only in a superficial way, may perhaps have surprised some readers. For it cannot be denied that ramifications of internal parts are by no means rare. As examples may be cited: branching cellular elements like the sclereids in the mesophyll of the leaves of *Camellia japonica* and the latex cells of *Euphorbia*, the anastomosing complexes of latex vessels in the fruit of *Papaver* and the root of *Scorzonera*, or the anastomosing meristeles in schizostelous parts like leaves and stems of *Ferns*. In the first cited cases of cellular elements the divisions have been formed by unequal growth of several parts, just as in the ramifications of external parts with which organography is concerned. In the cases like anastomosing latex vessels or meristeles on the other hand, the internal ramifications are not the consequence of unequal growth, but of unequal differentiation of several parts of the originally uniform meristem. But in neither case have these internal ramifications given rise to terms brought forward in the Synopsis and therefore there seemed to be no need for inserting a special article on internal ramification.

M. N. No. 10. (cf. S. No. 78). Sporangia and fructifications. The division of secondary reproductive organs into two categories, the first consisting of organs directly producing spores or gametes, the second designated by the term fructifications, as defined in No. 78 of the synopsis, leads in my opinion to the formation of two very natural groups of organs. Natural groups, however, often do not exhibit sharply defined differences, so that there may occur cases in which it seems at first sight difficult to come to a decision concerning the group in which certain members ought to be placed. Such cases are afforded by the sporogonia of *Bryophyta* and the fructifications of *Myxomycetae*. The sporogonia often exhibit a very complicated structure and might be considered from this point of view as thalloid fructifications. On the other hand the fructifications of *Myxomycetae* are often so very simple, that they might be and often have been considered as sporangia, while for the more complex cases (*Aethalium*) the term synangia would seem appropriate. But consulting the synopsis we find that the difference between sporangia and fructifications is in the first place to be found in the fact that the former have a less distinct vegetative character, while fructifications in their origin must distinctly belong to the vegetative region of which mostly a larger, or in a few cases a smaller (for instance horizontal scales from which podetia arise in *Cladonia*) part remains discernible. As a secondary character more or less connected with the fundamental one mentioned above, sporangia in general have a more simple and fructifications a more complicated structure. Bearing in mind the relative importance of both characters we will come to the conclusion that sporogonia ought to be considered sporangia and that in the case of *Myxomycetae* the term fructification ought to be preferred.

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[1]) Hofmeister. Allg. Morphologie der Gewächse, Leipzig 1868. p. 434 footnote 1.
[2]) Sachs. Lehrb. d. Bot. 4th ed. 1874. p. 189.

In sporogonia the relation to a vegetative region from which it might have been metamorphosed cannot be indicated and this is but natural when we keep in mind that the nutritive functions in a sporogonium are not prominent, because it lives partly and often almost wholly as a parasite on a gametophyte. On the other hand we find that all the principal characters of a sporogonium, however complex, have a certain importance for the production and dispersal of the spores, so that no doubt, though it is in many cases highly differentiated, nevertheless a term designating an organ directly producing spores must certainly be called appropriate. That it represents a complete sporophyte in the alternation of generations cannot prevent us from calling the sporogonium a sporangium, the less so as fructifications may in some cases belong to gametophytes, in others to sporophytes.

With respect to *Myxomycetae* it is an undeniable fact that the spore-receptacles arise by a transformation of the vegetative region. The originally subterranean plasmodium is quite used up in the formation of spore-producing organs, so that not even a part of the vegetative region remains in its original form. Here the fundamental character of a fructification is directly to be found. It is true that the differentiation of these receptacles may often not exceed that of many sporangia, but in other cases complicated and very large bodies, so called aethalia, are formed, while moreover several other cases of simple fuctifications like those of *Fucus* and many *Fungi* may be cited. For these reasons I have not hesitated to call in the synopsis the spore-producing parts of *Myxomycetae* fructifications and their walls peridia. It is true that in this respect I do not agree with Lister, who in his admirable Monograph of the Mycetozoa (1894, p. 11) used the terms sporangia and sporophores, but on the other hand Strasburger in his Text-book (Eng. ed. 1908, p. 540) describes the spore-receptacles of *Myxomycetae* as fructifications and their walls as peridia, though he does not quite avoid the term sporangia.

M. N. No. 11. (cf. S. No. 78). Fructification. This term is often mentioned in Botany, but not always in the same sense. In the first place of course it is used in a general way for designating the act of bearing fruit. But more frequently it is used for designating certain parts or organs of plants which are concerned with reproduction. In these cases it is often said to designate any sporogenous structure or collection of sporogenous structures [1]). In the Synopsis however the reader will find that I have used this term in a more comprehensive and more general sense, and this has proved to be very useful so that the term has become a somewhat prominent feature of the terminology of the organographical system. It is scarcely necessary to observe here that the term fructification does not imply that such an organ belongs either to a sporophyte or to a gametophyte or to a haploid or diploid generation as the examples of *Marchantia polymorpha* and the inflorescences and flowers of higher plants may sufficiently demonstrate.

Many plants produce several kinds of spores of which one is considered the most important. Thus in *Pyrenomycetes* the formation of perithecia producing asci is often preceded by the abstriction of various kinds of asexual conidia; likewise in *Basidiomycetes* the basidiospores are often accompanied by asexual conidia (uredospores, brand-spores, etc.) and in all such cases the term accessory fructification is often used. It is almost superfluous to mention that here the term fructification is used in its most general sense for the "act of bearing fruit" and by no means in the sense given to it in the system of organography of the Synopsis.

M. N. No. 12. (cf. S. No. 128). Procarp. This term was originally intended by Schmitz and some other authors to designate an organ formed by the union of cells belonging to the carpogone with the so-called auxilliary cells. The term carpogone is used by many authors for the whole female organ consisting of the basal part containing the egg-cell or egg-cells together with the trichogyne. Sachs in his text-book 4th edition 1874, p. 241 etc. and Oltmanns in his Morphologie und Biologie der Algen II, p. 373 used the term carpogone in this sense. Goebel in his Outlines of classification etc. Eng. ed. 1887, p. 7 and 485 uses the terms procarp and carpogone in a somewhat modified sense and his example has been followed in the Synopsis. The term procarp by this modification has received a wider sense, while the term carpogone has been restricted to a narrower sense, thus becoming free for serving as a counterpart to the ascogone.

M. N. No. 13. The subject of the following note exhibits a very general and chiefly historical character and therefore has not been mentioned in any of the articles of the Synopsis.

Thallome and Cormus (caulome and phyllome). These terms, as they are used in the Synopsis, were introduced into Botany by Sachs [2]). The terms thallus and cormus formerly were used in Botany to designate respectively the simple flat body of many *Crypto-*

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[1]) K. Goebel, Outlines of classification etc., Oxford 1887, p. 480.

[2]) Sachs. Lehrb. d. Bot. 4th ed. 1874. p. 151 and especially p. 153, 154.

gams and the stem or caulis as contrasted with the root and leaf ¹). Endlicher in his Genera Plantarum 1836—1840 p. I and III first uses for the principal divisions of the vegetable kingdom the names Thallophyta and Cormophyta and gives the following diagnoses: Regio I. Thallophyta. Oppositio caulis et radicis nulla, organa sexualia nulla, sporae germinantes undique elongatae. Regio II: Cormophyta. Caulis et radicis oppositio polaris. Vasa et organa propagationis sexu distincta in perfectioribus. From these descriptions it is clear that Endlicher uses the terms thallus and cormus in the sense as botanists generally did at that period. It is curious however that Endlicher places the cohort of *Anophyta* comprising *Hepaticae* and *Musci* in the regio of *Cormophyta*, though a contrast of stem and root does not appear in this group. Sachs no doubt derived his terms thallome and cormus from Endlicher's names, but at the same time he made an important change in their meaning by introducing the opposition between caulome (stem) and phyllome (leaf). Thus the term cormus received the meaning in which it is now commonly used, viz. that of a stem with its leaves. In the meantime Endlicher's terms Thallophyta and Cormophyta are becoming somewhat obsolete in systematic Botany, whilst they are not adapted to use in Organography, because all plants exhibiting cormi in a certain phase of their developmental cycle, exhibit in another phase the form of a thallome (protonema of *Mosses*, prothallia of *Pteridophyta*, etc.) and therefore might be called with the same right Thallophyta.

In conformity with the descriptions given in the Synopsis there is not the slightest doubt that with Hofmeister and Sachs we may use the terms cormus, caulome and phyllome not only in describing the bodies of *Gymno-* and *Angiospermae*, but also those of *Musci* (gametophytes), those of *Sargassum* and probably also those of *Caulerpa* and a few other *Algae*.

A different opinion however has been ventilated ²) and has found its way into more than one botanical text-book ³). It is more or less a return to the groups of Endlicher, for it comprises the view that the term cormus cannot be used for a stem with its leaves only, but that a root is needed in order to make it complete. It is further concluded that the leafy stems of the gametophytes of *Musci* do not exhibit true caulomes and phyllomes, but are rather to be considered as complicated examples of thallomes. It is said that their apparent leaves are not organs homologous, but in fact analogous to the leaves of the higher plants. This opinion concerning the gametophyte of *Musci* well deserves our attention, because it has a far reaching significance for Morphology. In this science we are wont to consider as especially valuable those characters which are concerned with distribution, reciprocal arrangement and mode of development and which we have called organotactical characters or organotactics, and the terms cau-

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¹) Bischoff. Handb. d. bot. Terminology und Systemkunde, Nürnberg, II. 1842, p. 586; I. 1833, p. 123.

²) Velenovsky. Vergl. Morphol. d. Pfl., Prag, 1, 1905, p. 150.

³) Strasburger Lehrb. d. Bot. 1923: Fitting, Morphology, p. 70 and 72.

lome and phyllome have been founded on descriptions containing in the first place characters of such a kind (see Synopsis S. No. 73). Now, if we compare the leaves of *Musci* and those of higher plants with one another, we find that both agree equally well with the organotactical characters brought forward in the description of phyllomes. Therefore we may ask what is the reason, that some authors at present do not consider the gametophytes of *Musci* as cormi, neglecting thereby a considerable number of facts which in modern Morphology are considered as fundamental and probably in a general way may be considered as fundamental facts by these authors themselves?

We find that as a principal argument the fact is brought forward that stem and leaves of *Musci* constitute the gametophyte, while in higher plants they constitute the sporophyte. It seems that this undeniable fact is considered in itself an argument, although in my opinion this cannot be conceded, because different explanations of it are possible. It is therefore in the first place necessary to look for differences between gametophyte and sporophyte which are of sufficient importance to suppress all ordinary morphological notions. After all, gametophyte and sporophyte are only phases of the same developmental cycle and naturally show in many respects the same constitution, so that the problem to be solved does not promise to be a very easy one. As far as I can see the only notable difference between gameto- and sporophytes throughout the vegetable kingdom is that in most cases the first is the haploid, the second the diploid generation. But it is highly improbable that this circumstance will have any direct effect on the fundaments of the reciprocal relation of caulome and phyllome. According to our present knowledge, the haploid nuclei of the gametophyte contain a complete set of chromosomes, at least in the vegetative organs. A complete development of these organs therefore seems always possible. On the other hand our knowledge of the more or less anomalous increase of the number of chromosomes in gameto- and sporophytes, though indeed showing some effects on caulomes and phyllomes, nevertheless gives proof that such an anomalous number does not alter their fundamental qualities and differences. As examples proving that with a larger number of chromosomes the reciprocal relations of caulome and phyllome remain the same I may cite: 1. the semi-gigas- (triploid) and gigas-varieties (tetraploid) of *Oenothera* and other plants; 2. diploid gametophytes etc. of *Musci* in the experiments of El. and Em. Marchal, (1907—1912); 3. the several varieties of *Datura Stramonium* described by A. F. Blakeslee [1]). Thus I cannot see that a good argument may be brought forward in support of the hypothesis that the organs of a gametophyte, when in a morphological sense comparable to those of a sporophyte ought nevertheless on account of their different origin to be considered as incomparable.

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[1]) A. F. Blakeslee. Variations in Datura due to changes in chromosome number. Amer. Nat. 56, 1922, p. 16.

A second argument why caulomes and phyllomes of *Musci* and higher plants cannot be considered as organs of the same kind is found by some authors in the fact that their internal cellular structure is very different and notably that in *Musci* it is much simpler. It is however a well-known fact that there exists by no means a close correlation between external organisation and anatomical structure. It is not my intention to go into detail in treating this fact; it may suffice to remind the reader that scale leaves without meristeles or petals without mesophyll in their intervenia, are nevertheless considered by everybody as phyllomes. But apart from all preceding considerations, I cannot think that any botanist who keeps in mind the true nature of the gametophytes in *Musci* can hesitate to conceed that their nature is a cormoid one. When we see how the gametophyte of *Climacium dendroides* is a triplocaulescent plant exhibiting three distinct kinds of cormus-individuals and how a cataphyllary region, a middle region, a region of phyllomes enveloping gametangia and a region of gametangia occur, perfectly comparable to similar organisations in higher plants, all doubts concerning the cormoid character of the gametophyte of *Musci* certainly must vanish. Summarizing, we may conclude that there are no grounds for denying the existence of true caulomes and phyllomes in *Musci* and that we may safely apply the well-tried ordinary morphological method in this case. For us the general occurrence of caulomes and phyllomes throughout the vegetable kingdom is a proof of the paramount importance of this differentiation from a morphological point of view and this assertion is confirmed when we find that the development of a cormus is not limited to the sporophyte, but may be observed also in the haploid gametophyte of *Musci.* I think that this is the more simple and reliable conception.

Finally it is obvious that in our case there is no reason to revive the system of Endlicher by claiming for the use of the term cormus the existence of a root.

M. N. No. 14. (cf. S. No. 147). Prothallium. This term is often used in Botany for designating all thalloid gametophytes, whilst the first phase of the gametophyte of *Bryophyta* is designated by the term protonema. These protonemata, although generally filamentous have nevertheless often a tendency and even a very strong tendency to appear as foliaceous thalli and in these cases the term prothallium is often applied in the course of description, as for instance in Engler und Prantl's Pflanzenfamilien, 2. ed. vol. 10, passim. Thus in Botany the term prothallium has obtained a somewhat wide meaning and the definition given in the Synopsis has been chosen in conformity with this state of things.

M. N. No. 15. (cf. S. No. 216). Compound phyllomes. Formerly the terms common petiole and petioles of the second and higher orders were generally used for indicating the petiole of a compound phyllome together with the part which has been indicated in the Synopsis by the term rhachis. I think that the latter terminology, taking better account of the difference between petiole and blade, is the more correct and that moreover it has been sufficiently adopted in botanical and palaeontological literature, so that we are justified in dropping the older term.

M. N. No. 16. (cf. S. No. 242). Cormus-individual. Almost three quarters of a century ago Alexander Braun published a treatise [1]) on the "Plant-individual", "Order of sequence of generations" and "Alternation of generations" which at the present day still remains of the utmost importance for the morphology of the higher plants. It is true that it contains some highly theoretical and philosophical remarks and expressions which were in vogue in those days, but which are no longer considered as current coin in modern Botany and it is likewise true that the plant-individual in Braun's sense as the true and single unit out of which the species can be built up has become for us a philosopher's stone no longer to be desired. But for all that Braun's paper in my opinion is one of the most beautiful and suggestive ever written in morphological Botany. He decisively proved that there are cormus-individuals (cormus = Sprosz of Braun) of various kinds, but always well-defined and this proof is strongly corroborated by the several spatial relations between cormi reciprocally and their constituent members, viz. caulomes and phyllomes, dealt with in the synopsis. If Braun's views are accepted it follows that in the higher plants the principal part of the body mostly exhibits a simple alternation of generations, and this certainly is a very interesting conclusion which however has not yet been generally accepted in modern Botany. It is true that his results concerning the order of sequence of cormus-individuals are mentioned in modern text-books, but as yet the influence of his conclusions on phytography seems to have been insufficient. Braun's injunction (p. 4) that we should begin at the beginning and not — skipping over the principal relations of the cormoid system (Stock of Braun) — lose ourselves in the dissection of the separate parts, has by no means found general application. Some analogies between this simple alternation of generations in plants and the phenomena called alternation of generations in the animal kingdom as exhibited by some *Coelenterata* and plant-lice certainly exist, but important differences are not wanting, chiefly in consequence of the greater closedness of individualization in animals.

M. N. No. 17. (cf. S. No. 251). Succession of cormi or order of sequence of cormus-individuals. In his celebrated treatise on the plant-individual cited in the preceding morphological note, Alexander Braun has conclusively shown [1]) that cormi exhibit a strong tendency to individualization and that, corresponding to the performance of certain functions, a differentiation of several cormi has taken place in many plants. This differentiation has a plastic rather than an organotactical character, so that it is not very important with respect to systematical Botany. Thus we find that *Papaver nudicaule* is a diplocaulescent plant, because the flowers appear as distinct cormus-individuals, whilst *Papaver somniferum* is haplocaulescent, because the flower is produced by the same cormus-individual which bears all other phyllomes of the plant. In dioecious plants we sometimes even see that the order of sequence of cormus-individuals is different in male and female plants; in *Carex dioica* for instance the male plant is diplocaulescent, the female on the other hand triplocaulescent.

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[1]) A. Braun. Das Individuum der Pflanze in seinem Verhältniss zur Species. Generationsfolge, Generationswechsel und Generationstheilung der Pflanze. Abhandl. d. K. Akad. d. Wissenschaften, Berlin, 1853. The reprint of this paper in my possession is a somewhat classical one, as it contains a dedication of Braun to his friend and teacher von Martius, whilst it belonged afterwards to the library of Eichler.

Nevertheless the order of sequence of cormus-individuals is a character of the highest importance if we wish to know the real construction of the complicated bodies to be found in most of the higher plants and *Musci.*

Some historical remarks may be added here concerning the use which has been made in Botany of Braun's very important discovery. It certainly cannot be said that it has been forgotten or has come into disuse during the seventy-five years of its existence. It has been mentioned in modern text-books, for instance in those of Pax [2]), Velenovsky [3]) and Strasburger [4]). Moreover it has been largely used by Eichler in his Blüthendiagramme and also in many papers on special subjects of systematical botany, for instance in Dingler, Die Flachsprosse der Phanerogamen, 1885, Engler und Krause, Araceae in Das Pflanzenreich, 1905—1920 and it would be easy to cite other instances of the same kind. On the other hand it is a curious fact that in several text-books, which appeared about the years 1860—1885 Braun's ideas concerning succession of cormi are either not at all dealt with or in so superficial a manner that their importance cannot at all be appreciated. The principal of those text-books is that of Julius Sachs, Lehrbuch der Botanik, of which the fourth edition appeared in 1874 and which served as an example for many other text-books. Moreover Asa Gray's Botanical Text-book may be cited, of which the sixth edition appeared in 1879: part I, entitled Structural Botany or Organography on the basis of Morphology. About the same period Oudemans wrote several text-books, beginning with a translation of Seubert's "Pflanzenkunde" (2. ed. 1857) and ending with Oudemans en de Vries, Leerboek der Plantenkunde, vol. 2, Vormleer en rangschikking, of which the first edition was published in 1883; the second edition of this work has often been cited in the Synopsis [1]).

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[1]) Prof. Schoute directed my attention to a passage in Flora 25, 1842, p. 692, where Hofmeister in a protocol concerning the botanical section of the twentieth Versammlung deutscher Naturforscher und Aerzte zu Mainz, communicates that Alexander Braun treated the succession of cormi already in all particulars in the same way as he did it eleven years later in "Das Individuum der Pflanze".

[2]) F. Pax. Allgemeine Morphologie, Stuttgart 1890, p. 23, Sprossfolge.

[3]) Velenovsky. Vergleichende Morphologie der Pflanzen, Prag, II, 1907, p. 592.

[4]) Strasburger and others. A text-book of Botany, 3. Eng. ed. 1908, p. 28 The order of sequence of shoots.

What are the causes that the views of Braun, so important for Botany, could not find their way into those and many other text-books? I am unable to give a well-documented answer to this question, but it is probable that two causes cooperated: in the first place it was a period of revolution, of vigorous development in physiology; microscopical research and Darwinism were going on with great force and the most active botanists took a less keen interest in morphological problems; in the second place Braun used in his paper on the plant-individual several more or less philosophical expressions [2]), not indeed dangerous in fact, but excommunicated soon afterwards and considered by the younger botanists of the new period to be certain proofs of ignorance and even dotage. It was the same philosophical turn of mind which induced Braun to consider his cormus-individual as the plant-individual, notwithstanding the most sensible remarks made by Aug. Pyr. de Candolle on the same subject many years before (cf. M. N. 4).

Be all this as it may, it is a deplorable fact that in those years whole generations of botanical students were educated without knowing Braun's views concerning the individualization of the cormus and simple alternation of generations. Speaking for myself I may say, that, as a pupil of Oudemans at Amsterdam and of Sachs at Würzburg, I entered the ranks of botanical teachers in a state of total ignorance of Braun's views and in this state I continued for nearly thirty years at the University of Groningen, writing a small book on Organography and educating in my turn students to the same degree of ignorance. It was only at the end of my career as a Professor, that preparing some lectures on the principles of Physiology I became acquainted with Braun's treatise. I am sure that some colleagues of my own age and probably of younger generations could relate a similar experience. Until the time of my conversion my eye saw in the higher plants leaf, stem and root. Now it sees in all higher and many lower plants, such as most Bryophyta, a cormus differentiated into individuals, which occurs both in sporophytes and gametophytes, as the principal part. It is only in the higher plants that a root is added to it, as secondary member whose morphological origin with respect to the cormus is by no means clear. On this head the reader is however referred to Morphological Note No. 26, dealing with the root.

M. N. No. 18. (cf. S. No. 252). Succession of cormi formula. The crumbs falling from Alexander Braun's table deserve to be gathered by botanists, because they may afford valuable food for thought. Thus when explaining the tabular matter of his classic paper "Das Individuum der Pflanze", he more or less incidentally uses a formula which he calls a "scheme". He tabulates longitudinal diagrams of a very special kind of the successive essential and non-essential cormus-individuals. The reader will find on our Plate III—VII a selection of these diagrams. Braun's schemes or formulae were simply explanations of his diagrams. It is however clear that such formulae may be very useful, even without the diagrams, and it is not to be wondered at, that they appear in many papers on systematical Botany.

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[1]) A complete list of the organographical publications of Oudemans, including also his Flora van Nederland, is to be found in Jaarboek 1909 Kon. Akad. Amsterdam in Moll, Levensbericht van C. A. J. A. Oudemans.

[2]) With respect to this point the reader's attention may be directed to page 25 et seq. of Braun's above cited paper.

Pax 1) in his Allgemeine Morphologie, dealing with the structure of the cormus-individual, called by him shoot, and cormoid systems, illustrates the two shapes in which the formula has hitherto been used in botanical literature by giving that of the triplocaulescent *Plantago major*, written out in its two modifications. I will reproduce them here, although the abbreviations which are used will be in conformity with those in No. 252 of the Synopsis, whilst Pax makes use of abbreviations corresponding to German terms, like N (Niederblätter) instead of Ca; L (Laubblätter) instead of F, etc.

The first specimen is as follows:

I: Ca, F, F ....
|
II: B, B ....
|
III: R-flower ♂ ♀

An objection against this formula is, that it more or less imitates a vertical diagram, thus losing its simple and direct character, without procuring in exchange any advantages of a real diagram. Formulae of a similar kind have for instance been used by Engler and Krause, in their Monographie der *Araceae* 2).

The second specimen is as follows:

I: Ca, F, F ....; II: (from F): B, B ....; III: R-flower ♂ ♀ from B.

The origin of II has not been mentioned by Pax, but has been added by me; the origin of III ought to have been noticed before R and not after it, but I have not judged necessary to make this alteration in the text.

The latter arrangement of the formula is in accordance with the form given by Alexander Braun to his schemes and is to be preferred, although it ought to be kept in mind that Braun's formulae were very short, since they were only intended for use in connection with his diagrams in order to explain the latter.

In a Pen-portrait however the succession of cormi is the first and important item in a description of the cormus, so that a preliminary investigation of this point is always necessary and this leads in a natural way to the construction of a formula, which deserves to be

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1) F. Pax. Allgemeine Morphologie, Stuttgart 1890. p. 26.

2) Das Pflanzenreich, IV. 23, 1905—1920, *Araceae*, B. p. 3.

placed at the head of the description giving necessary information to the reader about questions of the highest importance. It is clear however that for adaptation to such a more general use the formulae ought to be extended beyond the narrow limits drawn by Braun, in other words they should give an optimum of information concerning the character and the origin of the several generations of cormus-individuals. In the second place, although the use of some abbreviations is necessary, the formula ought to be capable of being understood without much preliminary technical knowledge, and theretore it is necessary to use only a small number of often recurring and easily comprehensible abbreviations, whilst especially the characters of the several cormus-individuals should be written in full. I think that the formulae, as suggested in the synopsis, will be in conformity with the conditions mentioned above.

M. N. No. 19. (cf. S. No. 255). Phyllotaxy. For students wishing to describe phyllotaxy according to our present knowledge of this difficult subject I hope that the article S. No. 255 in the Synopsis written by Dr. J. C. Schoute will be a useful aid, leading with the help of guiding scheme No. 31 by means of a relatively easy method to an up to date description.

The arguments which have led to this method may be found in several celebrated treatises of which a list is given here:

Alexander Braun. Vergleichende Untersuchungen über die Ordnung der Schuppen an den Tannenzapfen als Einleitung der Untersuchung der Blattstellung überhaupt. 1831. Nova Acta ph. med. Ac. Caes. Leop. Carol. nat. cur. 15, 1, p 196.

L. et A. Bravais. Essai sur la disposition des feuilles curviseriées. 1837. Ann. d. Sc. nat. sec. ser., Bot., 7, p. 42.

G. van Iterson Jun. Mathematische und mikroskopisch-anatomische Studien über Blattstellungen nebst Betrachtungen über den Schalenbau der Miliolinen, Jena, 1907.

It is of course impossible to give a detailed exposition here of the mathematical considerations which have led to the method worked out in the Synopsis according to the results of the brothers Bravais, but the student who consults the treatises cited above will be able to find his way to them, whilst in the meantime those who are prevented from making mathematical studies may accept a simple method for determining phyllotaxy worked out by mathematical and botanical authorities of the first order.

M. N. No. 20. (cf. S. No. 257 and 258). Vernation and Aestivation. It is well-known that Linné used these terms in order to indicate the several modes of coiling, overlapping, etc. of young leaves in buds. He designated by the term vernation phenomena occurring in spring in leafbuds and by the term aestivation the same in summer in flowerbuds. Lindley and Asa Gray defined both terms in accordance with Linné, though the latter in his Botanical Textbook clearly pointed out the difference between the connections of phyllomes with one another and the several modes of folding and coiling of individual leaves. Botanists afterwards brought these two categories of phenomena under separate heads, so that at present the term aestivation is used only for indicating the reciprocal spatial connections between several phyllomes, whilst the term vernation indicates the several manners in which individual phyllomes are folded or rolled up. In the synopsis this interpretation has been followed, whilst the terms prefoliation and prefloration have been set aside, because they imply a return to the original conception of Linné.

That the phenomena of aestivation and vernation in their present conception should be confined to buds is a mistake, which has however been made by many botanists. It is indeed true that elongated shoots bearing foliage leaves show aestivation only in the bud and that in the mature shoot nothing of aestivation remains, so that it would not be at all desirable to describe the condition of the mature leaves as exhibiting an open aestivation. With respect to vernation they could be described as plane, but this means in fact only that on this head nothing characteristic is to be observed and that it is superfluous to mention it.

But if we consider flowers, fruits, bulbs and tubers, it is at once clear that the phenomena with which we are here concerned are by no means limited to the bud stage, but may equally well appear in the mature state. In the flower of *Linum usitatissimum* the quincuncial aestivation of the calyx is exhibited not only in the bud, but also afterwards, so that mature fruits show it equally well in their remaining calyx [1]). Further it will be conceded, that the fruit of *Papaver* shows a valvular induplicate aestivation, that the carpels of *Leguminosae* and of *Iris* show a conduplicate vernation, etc., in all these cases combined with concrescence. The bulb of *Allium Cepa* shows a convolute vernation and that of *Lilium candidum* an imbricate aestivation of the scales.

For the material brought together in the synopsis I refer the reader chiefly to Lindley, An Introduction to Botany, third edition, 1839, p. 483 seq., Asa Gray, The Botanical Text-Book, Part I Structural Botany, p. 132 seq. and Oudemans en Hugo de Vries, Leerboek der Plantenkunde, Vormleer (by Oudemans) p. 88, seq. and p. 176 seq.

M. N. No. 21. (cf. S. No. 270). Spatial relations in a cormoid system; principal modes of junction. Eichler in his celebrated work entitled Blüthendiagramme used two terms: "Anschluss" and "Einsatz" for indicating the mode of junction between the phyllotaxy of the floral enveloping phyllomes and the parts below them. The term "Anschluss" or "Blüthenanschluss" designates relations in position, both in terminal flowers (I. p. 33) between the floral envelopes and foliage leaves (or bracts) occurring in lower regions, and in lateral flowers (p. 20) between floral envelopes and bracteoles. The term "Einsatz" (p. 21) or "Blütheneinsatz" on the other hand is used only for indicating in lateral flowers lacking bracteoles, the position of the floral phyllomes with respect to the podium of which the flower is a branch. Eichler of course limited his consideration of these subjects to the flower, although he occasionally cited examples of the mode of junction between the phyllomes of vegetative lateral cormi and their prophylls or podia.

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[1]) T. Tammes. Die Flachsblüte. Recueil trav. bot. néerlandais, Vol. 15, 1918, p. 192.

Fitting in his Morphologie [1]) uses the term "Anschluss" for designating in a general way the mode of junction of the phyllotaxy of a branch with that of its podium by means of prophylls. Thus he limited on the one hand the term "Anschluss" to lateral cormus-individuals with prophylls, whilst on the other hand he extended it to vegetative as well as floral branches.

I could not find an English translation of the terms "Anschluss" and "Einsatz" and a correspondence with Dr. Scott on the subject showed that these terms had not as yet been used in English botanical literature. Dr. Scott consulted Dr. Stapf of Kew Gardens, who had the kindness to suggest the terms synenthesis for "Anschluss" and enthesis for "Einsatz".

The reader will understand that in the Synopsis neither the term "Anschluss", nor the term „Einsatz" as they have been hitherto defined could be used. But consulting the Synopsis the reader will find that no special terms are needed here. The phenomena designated as spatial relations between lateral branches and their podia include indeed all relations indicated in the terms "Anschluss" and "Einsatz" by Eichler or Fitting and even something more. But the use of terms like those cited above is superfluous, because in a well-written pen-portrait all these relations will be fully described at their proper places by making use only of the well-known terms by which they are always designated.

M. N. No. 22. (cf. S. No. 306). Pedicel and peduncle. These terms are used in botanical literature rather promiscuously. Nevertheless both might be used with much profit in phytography if a somewhat more definite meaning were given to them. In the Synopsis I have tried to do this and I hope that thus they may be of some use.

M. N. No. 23. (cf. S. No. 330). Leeboards, sails, wings or alae. The term papilionaceous flower and the terms for the description of the papilionaceous corolla were both already used by Linné. The name of papilionaceous flowers, afterwards used for indicating the family of *Papilionaceae*, is a very appropriate one, because often the flowers more or less resemble butterflies. But for describing the morphology of the papilionaceous corolla another terminology has been chosen which has nothing whatever to do with a butterfly and is in its kind not less appropriate. In this case the corolla is compared to a vessel exhibiting a keel combined with two lateral petals, while there is a standard comparable to a flag. The Latin terms in use for these parts are the following: carina (keel), alae and vexillum (standard). The term ala has given rise to a somewhat curious confusion. It has been often translated as wing and the same translation has from the beginning also appeared at least in the Dutch, French and German languages (vleugel, aile, Flügel). Probably this translation has been chosen because the same corolla had been called papilionaceous, but it is clear that it is not appropriate for indicating two lateral parts belonging to a vessel. The word ala is used sometimes in poetical Latin as a metaphor indicating sails (velorum pandimus alas) or oars (volare remigis alarum); the latter term has however, as far as I know, never been used in Botany, but the term sails (Segel) is used by Bischoff, Handbuch der botanischen Terminologie und Systemkunde, vol. II, p. 333.

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[1]) Fitting in Strasburger's Lehrbuch der Botanik, 18. ed. 1931. p. 93.

Moreover I used in my Handboek der Plantbeschrijving (3. ed. p. 101) the term leeboards (zwaarden) and I still believe that this is the most suitable term, although it seems that the Romans did not know leeboards. Anyhow in the Synopsis I have retained the terms leeboards and sails, while for continuity's sake it seemed advisable not altogether to suppres the term wing, which has for so long a time been generally used.

M. N. No. 24. (cf. S. No. 361). Apocarpous and syncarpous gynoecium. The term apocarpous is sometimes used in botanical works not only for the gynoecium, but also for pistils and fruits. Examples are afforded by Asa Gray, Bot. Text-book, Part I Structural Botany, p. 261 and 262 and Jackson, Glossary, 2. ed. sub "apocarpous". But it is clear that the term apocarpous pistil cannot be used again for the simple pistils of an apocarpous gynoecium, when they are two or more in number. In likewise if we use the term apocarpous fruit for the three follicles together of *Aconitum Napellus*, it ought to be kept in mind that in organography this combination is not called a fruit, but that this term is reserved for each of the separate follicles. Therefore the use of the term apocarpous for designating certain pistils and fruits should be avoided.

On the other hand it is a fact that the term syncarpous gynoecium is indeed only a synonym indicating the same thing which may also be called compound pistil and therefore the use of the terms syncarpous pistil, ovary or fruit may be tolerated.

M. N. No. 25. (cf. S. No. 402). Testa or spermoderm. The morphology of the seed-coat, as it has been dealt with in the synopsis, is not quite in conformity with the views of the older botanists who have laid the foundations of modern organography. The reader interested in this subject may be referred to the excellent explanations given by Lindley, in his Introduction to Botany 1839. pag. 244; and afterwards by Asa Gray, in his Botanical Text-book, Part I;

Structural Botany or Organography on the basis of Morphology, pag. 306. In later works however, for instance of Warming, the terminology of the seed-coat has been simplified, so that at present the term testa has become a synonym of spermoderm, while the terms tegmen, endopleura and inner seed-coat and also exopleura, outer and external seed-coat have been suppressed.

M. N. No. 26. (cf. S. No. 425 and 426). Root. Our knowledge of the root is somewhat disproportionate in so far as it is fairly complete in one respect, whilst in two other respects it is very defective. It will be necessary to deal with anatomy, physiology and organography of the root separately.

1. Anatomy of the root. The internal structure of the root is almost as well-known as that of the cormus and although it presents a greater uniformity of differentiation, it nevertheless exhibits in a general way the same complicated character.

2. Physiology. Our knowledge of root physiology has on the other hand remained in a very imperfect state, so that there exists uncertainty about the most important functions of roots.

Dr. K. Zijlstra, Director of one of our agricultural stations, has for several years made a special study of root morphology and physiology, and for many of the particulars to be mentioned below I am indebted not only to his published papers, but also to verbal communications concerning investigations which are still in progress, but not yet ready for publication. The absorption of water and nutrient substances is in some respects an open question. At present many botanists are of opinion that the absorption of water exclusively or chiefly takes place by means of the root-hairs. Sachs strongly supported this theory, although it was not in harmony with investigations of older botanists, like Sénebier and others, whose experimental researches seemed to show that a very sufficient absorption might take place through the growing apex of the root. In later years Coupin [1]) has shown that the opinion of the older authors regarding this subject was perfectly true, and Dr. Zijlstra tells me, that he has been able by his experiments to confirm Coupin's views.

With respect to the functions of root-hairs it is highly probable that their power of absorption, if existing at all, is anyhow a function of secondary importance. On the other hand Dr. Zijlstra has found that in roots of *Gramineae*, root-hairs do not only cover the apical parts, but that their presence extends over the whole length of these roots, amounting in the primary root to half a meter and more. He is inclined to the opinion that root-hairs are very useful in firmly fixing the root in the earth, so that its apex in growing downwards can over-come considerable resistances, whilst seeking its way between the particles of the soil. A single root-hair affords only a minimum of resistance, but there are thousands of them and thus the root may be firmly fixed according to the method of the inhabitants of Lilliput for immobilizing Gulliver.

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[1]) H. Coupin, Sur le pouvoir absorbant du sommet des racines (Comptes rendus 168, 1919, p. 519—522); Sur le lieu d'absorption de l'eau par la racine (ibid. p. 1005—1008); Sur l'absorption des sels minéraux par le sommet de la racine (ibid. 169, 1919, p. 242). See also St. Popesco, Recherches sur la région absorbante de la racine. Bull. Agric. Bucarest 1926, 4, 135 pp. 86 fig. in the text; and the same author and title (Comptes rendus Soc. biol. 96 (13) p. 1031—1033).

I think that with regard to this question the roots of *Palms* could afford valuable information, and by a letter I received from Dr. P. M. L. Tammes, belonging to the scientific staff of the experimental station for *Cocos nucifera* at Menado, this supposition is corroborated. The hemispherical base of the stem producing up to 8000 adventitious roots seems an interesting object for investigations concerning the union of roots with the soil in which they live.

Another open question is that concerning the relation of root-growth and root-function with the conditions occurring in the depths of the soil. On one hand it is a fact that beneath asphalted roads in a soil devoid of free oxygen and often containing rather large amounts of carbon dioxide, roots can freely grow, but how this should be possible is not very well-known. The possibility that some anaerobiotic phenomena take place in such roots cannot be excluded and deserves examination, but on the other hand it is certain that Goedewaagen and Zijlstra [1]) have found in the protophloëm of roots peculiar longitudinal vessels which have lost their whole protoplasmic contents and may probably be filled in the living root with gases. These vessels may perhaps perform the function of passages through which air may be conducted from the somewhat older parts of the root towards the top of the vegetative cone, reaching as they do till only 0,4 mm from its upper end. With the help of these vessels the necessary oxygen can perhaps find its way from the aerial parts of the plant towards the utmost tip of the root. Further Dr. Zijlstra has shown by experiments, not yet published, that indeed roots are able to grow in a surrounding medium which is practically free from oxygen, if the cormi to which they belong are growing in air.

Lastly the attention of students interested in these subjects may be especially directed to the older botanical literature. They will find good introductions into these matters by consulting A. P. de Candolle, Organographie végétale, I, Paris 1827, p. 89, 90 (Spongiolae radicales); p. 116—117 (poils radicaux); p. 260—266 (fonctions des racines); A. P. de Candolle, Physiologie végétale, I, Paris 1832, p. 62—71; C. A. J. A. Oudemans, Leerboek der Plantenkunde I, Utrecht-Amsterdam 1867, p. 536.

3. Organography. Our knowledge of root organography certainly is the most insufficient of all parts of organography. This is in the first place caused by the fact that roots are mostly hidden in the

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[1]) Goedewaagen en Zijlstra. De inwendige bouw der wortels van gerst (Hordeum distichum). Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations No. 30, the Hague 1926.

These peculiar vessels were called by the authors kite-cells, because in transverse sections they exhibit the shapes of kites, radially directed with their apices turned towards the periphery.

earth and require some rather difficult and disagreeable manipulations for bringing them into a state allowing a description of all particulars. It is true that to collect the necessary material for such organographical investigations always requires much labour, patience and time, and pen-portraits are in this respect especially exacting. For instance the collection of material sufficient for describing the cormoid system of a large tree is by no means an easy task, although no digging up, washing out etc. may be needed. In other cases it is necessary for making a good pen-portrait to possess a certain number of developmental stages. But it must be conceded that the collection of material fit for describing roots remains always a much more disagreeable and complicated process.

It is clear that the better knowledge of root physiology can only be reached by procuring in the first place good pen-portraits of subterranean root systems and in accordance with what has been mentioned above, the first step must be to devote in future greater care to the collection of uninjured and abundant materials for description.

In making pen-portraits the use of guiding schemes is essential, and in consulting them the student is coolly advised to do his duty and not to slip over the description of parts or characters promising difficulties. Thus he is compelled, whether he does like it or not, to direct his attention towards all characters which can possibly be presented by the object of his investigations. But abundant material is needed for this purpose and incompleteness in this respect is the death of the pen-portrait. The incomplete manner in which the root has been treated in the synopsis may be considered as a demonstration of the truth that in phytography the method of pen-portraits deserves by all means to be adopted in Botany, the sooner the better.

One of the most interesting objects of root organography is doubtless the root system of our Gymno- and Angiospermous trees and it is curious to see how little is known about this subject. It is mentioned that in such root systems there may occur a perpendicular, conical root, penetrating deeply into the earth and further there may be a certain, often very large number of horizontal branches remaining near the surface and often covering a large area on one or more sides of the stem, so that these roots are very important for the growth of the tree. But concerning the origin of these more superficial roots, very little is known.

Two examples may be cited for proving the truth of this remark.

Firstly, in the botanical garden at Groningen a ditch was cut at a distance of about seven meters from several large trees, and after some years horizontal roots had reached the ditch and perforated a layer of clay with which the walls were lined for preventing loss of water, and the consequence was that the impermeability of this layer was perceptibly lessened.

A second case of the same kind was observed by Prof. J. C. Schoute, who saw in a nursery garden at Bussum a heap of decaying leaves in the vicinity of some trees and observed that those trees had sent numerous roots perpendicularly upwards, penetrating more than two meters into the nutritious mass. Numerous examples of the same kind might be cited and it is a fact that the origin of such superficial root systems is unknown; they may be parts of the primary root, or adventitious roots of some kind or other, for aught we know. We may say that botanists in general have fought shy of root studies. A curious instance of this kind is afforded by the work of Prof. Marshall Ward: Trees, a handbook of Forest-Botany for the woodlands and the laboratory, Cambridge, 1904—1909; he has described in five small volumes all parts of trees with the exception of the roots.

When a staff of young botanists, well versed in the art of making pen-portraits shall have arisen in future, such lacunae in our organographical knowledge of roots will soon be filled up. For the present however the result of all this has been that the organography of the root has remained in a state less favourable than that of the cormus two or three centuries ago. About that time the description of cormi was only in the first stages of its development, but this lack was largely supplied by a profusion of beautiful drawings, which are almost completely wanting for that hidden organ, the root of the plant.

Lastly the question remains to be answered in how far foresters with their well developed practical knowledge concerning the roots of trees, can help the botanist who wishes to make a pen-portrait in reaching his aim. It is certain that in modern forestry stations abundance of material for such investigations is always at hand: individuals of the common forest trees in all stages of early development from the seed upwards. Directors of such stations will doubtless be disposed to furnish the necessary material for botanical investigations of this kind. It is however no wonder that where botanists have hitherto been unable to afford them the sufficient knowledge of root organography, foresters have confined themselves to studies from a more practical point of view. The aerial parts of trees on the contrary have been described by botanists in detail, so that in these respects foresters were provided with a solid botanical basis for their own more practical investigations.

Prof. Weevers at Amsterdam who was interested in this subject, brought me into contact with Mr. E. Hesselink, Director of the state Forestry Station at Wageningen. This gentleman has made careful and elaborate investigations concerning the root systems of *Pinus silvestris* and *Pinus Laricio Austriaca* 1) and kindly directed my attention towards a paper of Erkki Laitakari, concerning *Pinus silvestris* 2).

The attention of botanists who wish to make pen-portraits of root

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1) E. Hesselink, Een en ander over de wortelontwikkeling van de grove den (Pinus silvestris) en de Oostenrijksche den (Pinus Laricio Austriaca). Mededeelingen van het Rijksboschbouwproefstation 2, p. 187—278, 1926, with German summary.

2) E. Laitakari, The root system of Pine (Pinus silvestris). A morphological investigation, Finnish with summary in English. Acta Forestalia Fennica 33. Helsingfors 1927.

systems is directed towards the above publications, which will no doubt afford them many useful communications.

M. N. No. 27. (cf. S. No. 455). Histology. In my preceding publications[1]) the term Histology has been used in another sense than that which has been given to it in the Synopsis. Some explanation of this fact is wanted. About the year 1906 I was writing for the work of Dr. Janssonius on Javanese woods a general introduction containing a description of the anatomy of secondary xylem and its terminology, which may be considered as a fore-runner of the Synopsis now offered to the botanical public. My late friend Prof. Pekelharing of Utrecht had published in the year 1905 his text-book of medical Histology (Voordrachten over Weefselleer, Haarlem), and in consultations on these matters he had soon convinced me that he was right in claiming for the comparative knowledge of cellular elements constituting tissues, a more or less independent place in the anatomical discipline. He who investigates the characters and origin of a certain kind of brick does other work than he who studies the architecture of the work of art built with these bricks (l.c. p. 11). Pekelharing's opinions on this head were of the greatest value for my work. By applying them in my lectures and in the description of secondary xylem cited above I was at once enabled to dispel the confusion concerning these questions which existed in my mind and which has been dealt with in detail in the first chapter of this volume.

In accepting this view I took for granted that I ought at the same time to accept the terminology which Pekelharing had proposed in this respect. The subject-matter dealt with in his text-book was called by him Histology in opposition to Microscopical Anatomy, the latter comprising the internal cellular structure of more complicated organs, like muscles, bones, etc. Thus in my introduction to the book of Dr. Janssonius and in my Handboek der botanische micrographie the terms histology and microscopical anatomy took a prominent place, the former one comprising the knowledge of the several kinds of cells and their union into simple tissues, in conformity with Pekelharing's text-book.

In Botanical Pen-portraits the subject was treated in the preface more in detail and now the domain of histology was somewhat enlarged with the compound tissues, so that microscopical anatomy comprised only the subject of tissue systems: epidermis, ground tissue and stele as they constitute the organs belonging to external differentiation. In the glossary after each term mention was made of the chapter to which it belonged, either cytology, histology or microscopical anatomy, but these additions were made before the preface was written and thus correspond to the view taken in the preceding publications, so that compound tissues are mentioned as belonging to Microscopical Anatomy. When the preface was written I had altered my opinion and this phase was preliminary to a later one in which the term Microscopical Anatomy disappeared altogether. For in course of time several objections against the term Microscopical Anatomy were raised in my mind. In the first place it seems to suggest that Cytology and Histology are not Anatomy, although this of course cannot be what it really means. It is further a fact that in Zoology and human Anatomy the term is still often used for simply designating those parts of Anatomy for which microscopical investigations are needed. Moreover the term Histology certainly will always indicate the knowledge of tissues and it cannot be denied that those parts of Anatomy dealing with simple tissues, compound tissues and tissue systems are all connected with the knowledge of tissues, though starting from different points of view which however are clearly pointed out in those three terms. By and by I came to the conviction that it was not advisable to admit the term Microscopical Anatomy into Botany, where it had never been used and would certainly become a stumbling-stone. The anatomical part of the Synopsis was ready before this opinion had ripened, but I thought it worthwhile to remodel the chapters on Histology and Microscopical Anatomy and to fuse them together into a single chapter entitled Histology. The result was a decided amelioration in the distribution of the subject-matter, more natural and more in conformity with the facts. For the rest the question treated of here is wholly unimportant for the ordinary practice of Phytography. In the description of woods written by Dr. Janssonius or in our Botanical Pen-portraits there is no occasion to alter even a single word in consequence of those altered theoretical considerations. Their only effect is that a student becoming acquainted with histology by means of a synopsis in which the arrangement of subject-matter is a more natural one, will get within a shorter time a sounder knowledge.

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[1]) Moll and Janssonius, Die Mikrographie des Holzes, Allgemeiner Teil by J. W. Moll, 1906.

J. W. Moll. Handboek der botanische micrographie, Groningen 1907 and 2d ed. by J. C. Schoute, Groningen 1925.

Moll and Janssonius, Botanical Pen-portraits, the Hague 1923, p. 11.

M. N. No. 28. (cf. S. No. 626 and 666). Monogenous and polygenous growth, cambia and permanent tissues; transit celled growth, cambium and permanent tissue; transit celled secondary cork tissue. Schoute in his paper on phenomena of cell division in cambia[1]) for the first time distinguished what in the Synopsis has been called monogenous and polygenous growth, cambia and cork tissue; instead of the term "polygenous" however he used that of storied or tier-like cambium and cork tissue (Etagencambium, Etagenkork). Schoute's results and terms were generally adopted in Botany, as for instance attested by the paper of Maria Philip, Ueber die Verkorkten Abschluszgewebe der Monokotylen, Biblioth. Botan. Heft. 92. 1923, notwithstanding the fact that von Höhnel[1]) had introduced the term storied or tier-like arrangement for designating quite another phenomenon to be observed in secondary xylem, phloem and cambium (cf. Morphological Note No. 29). In course of time however it became more and more apparent that the choice of the term "Etagencambium" was not a happy one. Von Höhnel's term indicates the existence of true stories or tiers, which in a normal position of the stem extend in a horizontal plane with others above and below. Schoute's storied or tier-like cambium however does not indicate real stories or tiers, but only the semblance of them appearing in a transverse section, whilst the apparent stories are arranged somewhat irregularly and only in a radial, not in a vertical direction.

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[1]) J. C. Schoute, Ueber Zellteilungsvorgänge im Cambium. Verhand. Kon. Akad. v. Wetensch. Amsterdam, 2. sect. Vol. IX, No. 4. 1902.

Von Höhnel's terminology was accepted by Solereder (p. 962 and p 388) and Janssonius in his Mikrographie des Holzes has made an abundant use of it; it may be said that it has been generally adopted for designating a certain arrangement of elements in secondary xylem. The matter rested however till I was writing the Synopsis, when the mistake became more evident. Moreover at the same time under the guidance of Prof. Schoute, Dr. Beyer was investigating the storied arrangement of secondary xylem, phloem and cambium, and this work in the same laboratory led to discussions with Prof. Schoute and induced us to abandon the terms storied or tier-like growth, cambium and cork and to replace on Schoute's suggestion them by those used in the Synopsis. For further information concerning this question the reader is referred to Dr. J. J. Beyer's dissertation entitled Die Vermehrung der radialen Reihen im Cambium[2]). In this paper there is inserted on p. 648 a passage written by Prof. Schoute concerning this subject.

Only a very few recently created terms have been introduced by me into this Synopsis of general Morphology, but they were all of an innocent and obvious character, never replacing other terms which are generally accepted in Botany, for I consider it a principle of the first importance that the utmost continuity should be preserved in terminology. When nevertheless a single exception has been made in this case I think that it may be excused, because the term now abandoned, was indeed apt to cause confusion and the author of the term did himself wish to see it replaced by another.

M. N. No. 29. (cf. S. No. 673 and 691). Storied, tier-like, stratified or laminated arrangement of secondary xylem and phloem. Concerning the origin of these terms and the study of the phenomenon designated by them the reader is referred to morphological note No. 28. Here it may suffice to mention that the terms stratified and laminated have been used especially in American papers on this subject. With respect to the term laminated, see in "Bibliography of the Woods of the World" [1]) the index under the head laminated.

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[1]) F. von Höhnel. Ueber stockwerkartig aufgebaute Holzskörper. Kais. Akad. d. Wiss. I Abth. 89, Wien 1884.

[2]) Recueil des trav. bot. Vol. XXIV. p. 631.

M. N. No. 30. (cf. S. No. 676). Medullary rays. They are often mentioned in botanical literature as secondary medullary rays and authors expressing themselves in this way use the term primary medullary rays for those parts of the stele which are called medullary commissures in the Synopsis. In order to avoid confusion between parts of very different developmental characters the latter is certainly the better term. For the rest medullary rays in secondary xylem and phloem are of course always secondary tissues, but there is no need to mention this fact in the term.

M. N. No. 31. (cf. Preliminary notices to the Synopsis on p. 29). New technical terms. The number of technical terms appearing in the synopsis amounts to about 2500. It is certain that there exist many terms which are not to be found here, but the present number is no doubt sufficient for all ordinary phytographical work in a rather wide sense of the word. On the other hand a restricted number of new terms have been introduced, but in this respect great discretion has been used. Many of the new terms are only combinations of other terms or well-known words, or are even only old terms, which have received a new meaning; and where the introduction of new words could not be avoided, I have, if possible, always preferred the choice of words repeatedly used by authors in their papers, without promoting them to the rank of technical terms. A rather complete list of new terms of different kinds may be added here:

I. Organography.

Organotactics, instead of morphological characters as a counterpart of the existing term plastics. (see Synopsis No. 5).

Concerning the term individual the following modifications: reproduction-individual or ordinary individual, subordinate-individual or organ-individual (see Synopsis No. 9); homogeneous and heterogeneous individualization, complete and incomplete individual (see Synopsis No. 10); cormus-individual (see Synopsis No. 242).

Hofmeister's alternation of generations for antithetic and diplobiontic alternation of generations (see Synopsis No. 26).

Primary and secondary reproductive organs, fructifications (see Synopsis No. 78).

Independent and dependent divisions or ramifications of margin of blade (see Synopsis No. 210).

Periodic shoot (see Synopsis No. 249), and annual shoot (see Synopsis No. 250).

Cormoid system (see Synopsis No. 242).

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[1]) G. P. Ahern and H. K. Newton, A bibliography on woods of the world exclusive of the temperate region of North America and with emphasis on tropical woods, New York 1928.

Succession of cormi (see Synopsis No. 251), and succession of cormi formula (see Synopsis No. 252).

Virga singularis (see Synopsis No. 275).

Monopodial, sympodial and mono-sympodial bulb (see Synopsis No. 287).

Sympodial and mono-sympodial tuber (see Synopsis No. 293).

Leaf runners, inflorescence runners and submerged runners (see Synopsis No. 297).

Unicompound up to pluricompound inflorescences (see Synopsis No. 313).

II. Anatomy.

Common parenchyma cells. (see Synopsis No. 561).

Full meristems. (see Synopsis No. 620).

Transit celled growth, cambia and permanent tissues. (see Synopsis No. 626).

Medullary commissures; simple and compound vascular bundles. (see Synopsis No. 657).

Simple and compound medullary rays. (see Synopsis No. 678).

Endodermis in an altered meaning (see Synopsis No. 702).

Intermediate parietal layer (see Synopsis No. 721).

DIVISION III. GUIDING SCHEMES, SPECIAL ENUMERATION.

As has been set forth in the first Book, Chapter III, the phytographer ought constantly to keep in mind that these guiding schemes are good servants, but bad masters. They will show you a safe and easy way through the trodden paths of science, leaving your mind free to make new and original observations. Do not object to them on account of their prolixity; you may object to the use of a railway guide on the same account. Yet a man going to the railway station without having consulted his guide and hoping to find there his train just starting, has a better chance of success than a botanist has of making a good pen-portrait without using a guiding scheme. They are indispensable for making pen-portraits and a student undertaking this task must in the first place make a choice of those guiding schemes, which are adapted to his special case. For this reason the reader is referred to the following:

LIST OF GUIDING SCHEMES.

Group I. General subjects.

1. Grade of individuality of the object to be described. (p. 384).
2. Natural life-time of individuals.
3. Polymorphism, either individual or partial. (p. 385).
4. Grade of individualization in reproduction- and organ-individuals with respect to sex.
5. Symmetry characters. (p. 386).
6. Branch-systems. (p. 387).
7. General characters to be noticed in all phytographical work.

8. Other elementary characters for which no special terms are in use. (p. 389).
9. Special kinds of locomotion.

Group II. General Organography.

10. Early development stages. (p. 390).
11. Determination of reproductive organs.
12. Determination of primary reproductive organs, leading to a-sexual reproduction. (p. 391).
13. Spores.
14. Conidiophores, basidia and gametophores. (p. 392).
15. Unicellular sporangia, including asci.
16. Ordinary pluricellular sporangium. (p. 393).
17. Sporogonium.
18. Gametes. (p. 394).
19. Gametangia. (p. 395).
20. Development of a zygote into spores.
21. Sori and hymenia. (p. 396).
22. Parts to be described with respect to their position in the groups of homologous and analogous organs.
23. Disturbing and complicating phenomena in the course of development, during the division into organs. (p. 399).
24. Organographical description of appendages of the surface.

Group III. Special Organography.

A Thallome.

25. Determination and description of special forms of thallomes. (p. 400).
26. Description of a thallome. (p. 404).

B. Cormus.

27. Succession of cormi in cormoid systems. (p. 405).
28. Spatial relations in a cormoid system.
29. Spatial relations between lateral cormus-individuals and certain phyllomes belonging to their podia.
30. Spatial relations between prophylls of branches and their podium.
31. Phyllotaxy. (p. 406).
32. Mode of junction of the higher placed phyllomes to the prophylls.
33. Spatial relations between the spiral phyllotaxis of a branch and that of its podium. (p. 407).
34. Aestivation and plication.
35. Vernation. (p. 408).
36. Specially differentiated cormi.
37. Vegetative region of a cormus. (p. 409).
38. Cormoid bud.
39. Bulb. (p. 410).
40. Cormoid tuber. (p. 411).
41. Stolon or runner. (p. 412).
42. Cormoid receptacle.
43. Strobilus.

44. Anthotaxy.
45. Special kinds of inflorescences. (p. 413).
46. Description of inflorescences. (p. 414).
47. Flower. (p. 415).
48. Special forms of flowers. (p. 419).
49. Pollen. (p. 420).
50. Ovule. (p. 421).
51. Special kinds of fruits. (p. 422).
52. Description of fruit. (p. 423).
53. Seed and development of seedling. (p. 424).

C Caulome.

54. Special forms of caulomes. (p. 427).
55. Description of a caulome.

D. Phyllome.

56. Special forms of phyllomes. (p. 428).
57. Description of a phyllome. (p. 429).

E. Root.

58. Special forms of roots. (p. 431).
59. Origin of root or root system. (p. 432).
60. Description of a root.

Group IV. Cytology.

61. Description of cellular elements. (p. 433).
62. Mode of cell reproduction and description of cells in a state of reproduction. (p. 436).
63. Mode and phases of nuclear division and description of nuclei in a state of division. (p. 437).
64. Tetrad after reduction division. (p. 438).

Group V. General Histology.

65. Histological determination of single cells.
66. Vessels. (p. 439).
67. Mode of growth and formation of tissues. (p. 440).
68. Histological determination of a tissue. (p. 441).
69. Histological determination of meristems in their relation to adult tissues. (p. 442).
70. Histological description of meristems themselves. (p. 443).
71. Stomatic apparatus.
72. Emissaries (hydathodes). (p. 444).
73. Internal glands.
74. Primary vascular bundle. (p. 445).
75. Fibrovasal bundle. (p. 446).
76. Secondary cork tissue.
77. Secondary phloem. (p. 447).
78. Secondary xylem. (p. 448).
79. Secondary vascular bundle tissue. (p. 449).

Group VI. Special Histology.

80. Highly differentiated thallomes. (p. 450).

81. Caulome. (p. 450).
82. Phyllome. (p. 453).
83. Stamen. (p. 455).
84. Pistil and fruit.
85. Ovule. (p. 456).
86. Seed. (p. 457).
87. Root. (p. 458).
88. Appendages of the outer surface and the surface of internal cavities. (p. 460).

Group I. General subjects.

No. 1. Guiding scheme for determining the grade of individuality of the object to be described.

For meaning of terms consult synopsis No. 7—12.

1a. reproduction-individual, ordinary individual or individual without any qualification.
2a. general determination.
3a. homogeneous individualization with complete individuals.
3b. heterogéneous individualization with incomplete individuals.
4a. number and characters of incomplete individuals.
2b. plant-individual.
3a. practical conception.
4a. herb or herbaceous thallomes (for kinds of these see guiding scheme No. 25, Special forms of thallomes).
4b. tree or tree-shaped thallomes.
4c. shrub or fruticose thallomes.
3b. theoretical conception. See 2a, 3a, homogeneous individualization.
1b. subordinate or organ-individuals, showing heterogeneous individualization.
2a. number and characters of incomplete individuals. For determining the grade of individualization with respect to sex, consult moreover guiding scheme No. 4.

No. 2. Guiding scheme for indicating the natural life-time of individuals.

For meaning of terms consult synopsis No. 13, natural life-time of individuals.

1a. ordinary or reproduction-individuals.
2a. annual plants or annuals. ⊙ or ①.
2b. biennial plants or biennials. ♂ or ②, ⊙⊙, ⊙.
2c. perennial plants or perennials.
3a. perennial herbs. ♃.
4a. subterranean parts.
4b. aerial parts.
5a. annual.
5b. biennial.
3b. trees and shrubs.
3c. anabiotic plants.

- 2d. hapaxanth-monocarpic (D.C.) or haplobiotic (A. Br.) plants.
  - 3a. monocyclic.
  - 3b. dicyclic.
  - 3c. polycyclic.

1b. subordinate or organ-individuals.
- 2a. deciduous.
- 2b. persistent.
- 2c. permanent.

No. 3. Guiding scheme for the description of polymorphism, either individual or partial.

For meaning of terms consult synopsis No. 17—20 and 22—26.

1a. general individual polymorphism.
- 2a. seasonal dimorphism.

1b. modification (fluctuating variations).

1c. mutations.

1d. metamorphosis.
- 2a. heterophylly.
- 2b. anisophylly.
- 2c. juvenile forms of foliage leaves.

1e. graft-hybrids.

1f. in connection with reproduction:
- 2a. asexual.
- 2b. sexual.
  - 3a. hermaphroditism.
  - 3b. monoecism.
  - 3c. dioecism.
  - 3d. polygamy.

1g. alternation of generations.
- 2a. in general:
  - 3a. simple.
  - 3b. antithetic.
    - 4a. haplobiontic.
    - 4b. diplobiontic.
- 2b. in parasitic species:
  - 3a. autoecious.
  - 3b. heteroecious.

1h. variety in cellular elements.

No. 4. Guiding scheme for determining the grade of individualization in reproduction-individuals and organ-individuals with respect to sex.

For meaning of terms consult synopsis No. 21.

1a. asexual.

1b. sexual.
- 2a. general terms designating only the presence or absence of the two sexes.
  - 3a. bisexual, monoclinous or hermaphrodite.
  - 3b. unisexual or diclinous.

        - 4a. male.
        - 4b. female.
    - 3c. asexual or neutral.

2b. special terms for designating the distribution of the two sexes over separate ordinary individuals belonging to the same systematical or any other group.

    - 3a. monoecious.
    - 3b. dioecious.
    - 3c. polygamous.
        - 4a. andromonoecious.
        - 4b. gynomonoecious.
        - 4c. trimonoecious or coenomonoecious.
        - 4d. androdioecious.
        - 4e. gynodioecious.
        - 4f. trioecious or trioecious-polygamous.
        - 4g. pleogamous.

2c. special terms for designating the spatial distribution of sexual organs in hermaphrodite combinations.

    - 3a. dimorphous.
    - 3b. trimorphous.

2d. special terms for designating peculiarities concerning the period of maturity of sexual organs in hermaphrodite combinations.

    - 3a. homogamous.
    - 3b. dichogamous.
        - 4a. protandrous or proterandrous.
        - 4b. protogynous or proterogynous.
    - 3c. cleistogamous.
    - 3d. chasmogamous.

No. 5. Guiding scheme for the description of symmetry characters.

For meaning of terms consult synopsis No. 39—53.

- 1a. asymmetrical.
- 1b. symmetrical.
    - 2a. symmetry in arrangement.
        - 3a. cyclic or verticillate arrangement.
            - 4a. dimerous, trimerous up to polymerous whorls.
            - 4b. homomerous and heteromerous whorls.
            - 4c. alternation and superposition or opposition.
            - 4d. para- and orthostichies.
        - 3b. spiral arrangement.
            - 4a. parastichies and genetic spirals.
                - 5a. divergence.
                - 4b. orthostichies.
    - 2b. symmetry in shape.
        - 3a. polarity or polar symmetry; longitudinal or main axis.

4a. polarity of basis and apex. Acropetal (basifugal) and basipetal (acrofugal) succession of development.

- 5a. actinomorphy or radial symmetry.
- 5b. dorsiventrality, zygomorphy or bilateral symmetry.

- 5c. disturbed symmetry.
  - 6a. disturbances of dorsiventrality in leaves.
  - 6b. disturbances of dorsiventrality in flowers, or asymmetrical flowers.
- 4b. bipolarity.

No. 6. Guiding scheme for the description of branch-systems.

For meaning of terms consult synopsis No. 54—67.

- 1a. homogeneous branching.
  - 2a. exogenous development.
    - 3a. dichotomy (true dichotomy), trichotomy up to polytomy. Saddle.
      - 4a. sympodium.
    - 3b. monopodial branching (monopodium).
      - 4a. racemose branching (centripetal branching).
        - 5a. arrangement of lateral branches.
          - 6a. in cormi.
            - 7a. in connection with the phyllotaxy of the podia.
            - 7b. in connection with the presence of nodi.
            - 7c. without connection either with phyllotaxy or with the presence of nodi.
          - 6b. in roots in connection with xylem- and phloem strands.
            - 7a. number of orthostichies.
        - 5b. sympodium.
          - 6a. sickle or drepanium.
          - 6b. fan or rhipidium.
          - 6c. screw or bostryx.
          - 6d. cincinnus (cicinnus).
      - 4b. cymose branching (centrifugal branching).
        - 5a. monochasium.
        - 5b. dichasium (false dichotomy).
        - 5c. pleiochasium.
        - 5d. sympodium.
          - 6a. sickle or drepanium.
          - 6b. fan or rhipidium.
          - 6c. screw or bostryx.
          - 6d. cincinnus (cicinnus).
  - 2b. endogenous development. See 2a.
- 1b. heterogeneous branching. See 1a.
- 1c. adventitious branching. See 1a.
- 1d. reduction of branch-systems.
  - 2a. by means of absciss-layers.
    - 3a. period of removal.
    - 3b. lateral or apical branches removed.
    - 3c. age of removed branches.
    - 3d. length of same.
  - 2b. natural death of branches in bad conditions of nutrition.
  - 2c. more casual death of branches by accidents of all kinds.

1e. total length of podium of the first order and all branches together.
1f. false branching.

No. 7. Guiding scheme for the description of general characters to be noticed in all phytographical work.

For meaning of terms consult synopsis No. 30—37.

1a. shape.
  2a. polyhedron (faces, edges, vertices).
    3a. regular (tetrahedron, cube, octahedron).
    3b. pyramid (base, vertex, vertical or pyramidal faces, vertical edges), trihedral, tetrahedral up to polyhedral, truncated (bottom surface, top surface), skew truncated, frustum, regular or irregular pyramid.
    3c. prism (bottom surface, top surface, prismatic surface, basal edges, top edges, vertical edges), bottom and top surface parallel (rectangular, oblique), bottom and top surface not parallel (truncated), number of prismatic surfaces (tri- up to polyhedral), prism with rounded edges.
    3d. parallelepiped (rectangular, oblique).
  2b. bodies with curved surfaces.
    3a. cone (base, vertex, vertical or conical surface), circular (right, oblique), elliptical (right, oblique), truncated (bottom surface, top surface), skew truncated, frustum.
    3b. cylinder of undetermined length (circular, elliptical, arbitrary cross section) ; of finite length (right and oblique circular, right and oblique elliptical).
    3c. sphere, spherical segment, zone of a sphere, spherical sector, spherical wedge.
    3d. ellipsoid, 3-axial, of revolution (prolate, oblate).
1b. dimensions.
  2a. general abbreviations: m, dm, cm, mm, μ, $\mu\mu$.
  2b. abbreviations concerning directions of cells within the organs containing them: L, Tr, B, R, T, H, Lev., Lev. L, Lev. B.
1c. conditions of colour.

If some precision is wanted a suitable system of description ought to be chosen. See for this purpose synopsis No. 34.

1d. conditions of consistency.
  2a. herbaceous.
    3a. succulent.
  2b. woody or ligneous.

For other terms of this kind used in ordinary life, see guiding scheme No. 8, under 1b.

1e. conditions of surface.

If in the descriptions of surface terms used in ordinary life are needed, the reader is referred to scheme No. 8, under 1c. Moreover the conditions of surface may be differentiated:

  2a. in consequence of primary growth.
    3a. smooth or glabrous surface.

3b. appendages of the surface. See guiding scheme No. 24 for organographical description, and guiding scheme 88 for anatomical description.

  2b. in consequence of secondary growth.
    3a. secondary periderm.
      4a. scaly appearance.
    3b. rhytidoma, scaly-bark, size of scales.
    3c. scars of dehiscent parts, covered with secondary periderm.
    3d. lenticels.
    3e. cork-patches.
  2c. in consequence of wounds.
    3a. wound-cork.
    3b. resin, caoutchouc, gum etc.
1f. statistical data.
  2a. abbreviations: n, M, Med, q_1, Q_1, q_3, Q_3, min., max.
  2b. frequence curve.
    3a. normal.
    3b. skew.
    3c. compound.
      4a. bimodal up to multimodal.

No. 8. Guiding scheme for the description of other general elementary characters, important in phytography, but not mentioned in the organographical and anatomical guiding schemes, because no special technical terms are in use for them.

1a. shape. For instance: in bundles, cylindrical rolls, cone-like masses; slices, sheets, strips, shreds, flakes, cakes; curved, flattened, arched, tortuous, twisted, quilled (quills), channelled, gutter-shaped, barrel-shaped, laminated; etc.
1b. general elementary physical characters: hard, soft; leathery, dry, fleshy; flexible, elastic, tough, brittle, pulverisable; specific gravity; light, heavy, dense, compact; strength, splitting; translucent; burning (smell, crepitation, smoke, glowing).
1c. surface: rough, dull, shining, polished, bright, brilliant, fibrous, silky; striated, wrinkled, pitted, reticulated, fissured; touch (cool, warm, sticky either in a dry or in a wet state).
1d. fracture: clean, uneven, short, splintery, fibrous; radiate; resinous, mealy, laminated; colour; etc.
1e. section. See fracture.
1f. odour. When dry, wetted, warmed or freshly cut: aromatic, fragrant, warm, irritating, nauseous; etc.
1g. taste. For instance: bitter, sweet, acid, astringent, aromatic, warm, hot, burning, pungent, acrid, nauseous; oily, mucilaginous; gritty between the teeth; etc.
1h. extracts.

Group II. General Organography.

No. 9. Guiding scheme for the determination of the special kinds of locomotion.

For meaning of terms consult synopsis No. 15, locomotion.

- 1a. passive locomotion.
  - 2a. by means of water.
  - 2b. by means of air.
  - 2c. by means of animals.
- 1b. active locomotion.
  - 2a. by means of growth.
    - 3a. subterranean.
    - 3b. aerial.
    - 3c. submersed.
  - 2b. by means of special differentiations.
    - 3a. creeping movements.
      - 4a. amoeboid movements.
      - 4b. other progressive and swinging movements.
    - 3b. free swimming movements.

No. 10. Guiding scheme for the description of early developmental stages.

For meaning of terms consult synopsis No. 69—71.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. exogenous development.
  - 2a. primordium.
  - 2b. embryo.
    - 3a. foot.
      - 4a. remaining in the adult state.
      - 4b. soon disappearing.
    - 3b. hypophysis.
  - 2c. bud. See further guiding scheme No. 38, cormoid buds.
    - 3a. dormant.
    - 3b. active.
- 1b. endogenous development. See 1a.

No. 11. Guiding scheme for the determination of reproductive organs.

For meaning of terms consult synopsis No. 76—78.

- 1a. primary reproductive organs.
  - 2a. spores.
  - 2b. gametes.
  - 2c. parts leading to asexual reproduction.
- 1b. secondary reproductive organs.
  - 2a. organs directly producing spores and gametes.
    - 3a. conidiophores.
    - 3b. sporangia.
    - 3c. gametophores.
    - 3d. gametangia.
  - 2b. fructifications.

No. 12. Guiding scheme for the determination of primary reproductive organs leading to asexual reproduction.

For meaning of terms consult synopsis No. 117.

1a. parts without special differentiation with regard to reproduction.
  2a. in unicellular plants; cell-divisions followed by separation.
  2b. in pluricellular plants.
    3a. portions of the mother plant separated from it by more or less accidental means.
    3b. hormogonia.
1b. parts, specially differentiated with regard to reproduction.
  2a. in unicellular plants; cell budding, followed by separation of the buds.
  2b. in pluricellular plants.
    3a. spores and conidia of several kinds.
    3b. buds of a thalloid character.
      4a. soredia (sorales).
      4b. starch-stars.
    3c. buds of a cormoid character.
      4a. buds arising from a protonema.
      4b. buds growing out into aerial or subterranean runners or stolons.
      4c. buds arising from leaves.
      4d. buds arising from roots.
      4e. bulbils.
    3d. root-tubers (tuber-gemmae).
    3e. buds arising from appendages of the surface.
      4a. gemmae.
      4b. small tubers.
    3f. adventitious embryos.

No. 13. Guiding scheme for the organographical description of spores.

For meaning of terms consult synopsis No. 79—95.

General characters (shape, dimensions, chemical composition, colour, consistency, surface, statistical data) should be mentioned in their proper places; for describing them, consult guiding schemes No. 7 and No. 8.

1a. unicellular spores.
1b. pluricellular spores.
  2a. number and arrangement of cells.
1c. naked spores.
1d. walled spores.
1e. planospores. See guiding scheme No. 25, 1a, thallomes etc. with locomotion.
1f. aplanospores.
1g. endospores.
1h. ectospores.
1i. conidia.
  2a. basidiospores.

1j. chlamydospores.
  2a. smut-spores or brand-spores.
  2b. oidia.
1k. sporidia.
1l. resting spores.
1m. summer spores.
1n. teleuto- or winterspores.
1o. tetraspores.
1p. auxospores.
1q. asexual spores.
1r. spores related with sexual reproduction.
  2a. spores the direct result of a sexual fusion.
    3a. zygospores.
    3b. oospores.
  2b. spore formation preceded by reiterated cell divisions combined with reduction division.
    3a. carpospores.
    3b. basidiospores.
    3c. ascospores.
    3d. microspores, pollen-grains.
    3e. megaspores, embryospores.
1s. polarity of base and apex.
  2a. neutral spores, microspores and megaspores.
    3a. acroblastic.
    3b. basiblastic.
  2b. pollen-grains.
    3a. acrosyphonic.
    3b. basisyphonic.
  2c. embryo-sac.
    3a. acrogamic.
    3b. basigamic.
1t. pycnospores.

No. 14. Guiding scheme for the description of conidiophores, basidia and gametophores.

For meaning of terms consult synopsis No. 96 and No. 125.

General characters should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. simple or ramified.
1b. uni- or pluricellular.
1c. sterigmata.

No. 15. Guiding scheme for the description of unicellular sporangia, including asci.

For meaning of terms consult synopsis No. 97—100.

General characters should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. sporangium proper.
  2a. shape.

- 2b. wall.
- 2c. columella.
- 2d. contents.
  - 3a. spores. See guiding scheme No. 13.
  - 3b. other contents.

1b. sporangiophore.

- 2a. simple or ramified.
- 2b. uni- or pluricellular.

No. 16. Guiding scheme for the description of an ordinary pluricellular sporangium.

For meaning of terms consult synopsis No. 97, 98, 101—107.

General characters should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and 8.

- 1a. large sporangia.
  - 2a. microsporangia.
    - 3a. sporangium proper.
      - 4a. wall.
        - 5a. number of cell layers.
        - 5b. fibrous layers.
        - 5c. ring or annulus.
          - 6a. complete.
            - 7a. apical.
            - 7b. passing obliquely over the apex of the sporangium.
          - 6b. incomplete.
          - 6c. reduced.
        - 5d. tapetum (periplasm). See moreover 4b, 5b, 6c, 7b and 4b, 5b, 6d.
      - 4b. contents.
        - 5a. spores, pollen-grains, embryo-sacs (archesporium, sporogenous tissue, spore-mother-cells).
          - 6a. spore- or pollen-tetrads.
          - 6b. pollinia (tail or caudicle).
        - 5b. sterile parts.
          - 6a. trabeculae.
          - 6b. capillitium.
          - 6c. elaters.
            - 7a. cellular elaters.
            - 7b. tapetal or perinial elaters.
          - 6d. products of the tapetum.
            - 7a. massulae, interstitial substance (glochidia).
            - 7b. perinial or tapetal elaters.
    - 3b. stalk.
      - 4a. number and disposition of cells.
  - 2b. macro- or megasporangia. See 1a, 2a.
- 1b. sporangioles. See 1a.
- 1c. synangium. See 1a.

No. 17. Guiding scheme for the description of a sporogonium.

For meaning of terms consult synopsis No. 97, 99, 108—116.

General characters should be mentioned in their proper places; for describing them consult guiding scheme No. 7 and No. 8.

1a. calyptra or hood.
  2a. persisting as a basal sheath.
  2b. persisting as a cap on the theca.
1b. seta.
  2a. foot.
  2b. apophysis.
1c. theca or capsule.
  2a. wall.
    3a. number and differentiation of cell layers, fibrous layers, stomata.
  2b. columella.
    3a. confined to basal part of theca.
    3b. extending to top of theca.
      4a. epiphragma.
    3c. differentiation of cells.
  2c. spore-sac.
    3a. shape and position.
    3b. external spore-sac.
    3c. internal spore-sac.
  2d. contents.
    3a. spores.
    3b. cellular elaters.
1d. dehiscence.
  2a. decay of the wall.
  2b. valves.
  2c. teeth.
  2d. clefts.
  2e. operculum or lid.
    3a. annulus or ring.
    3b. peristome.
      4a. outer (teeth).
      4b. inner (cilia).

No. 18. Guiding scheme for the description of gametes.

For meaning of terms consult synopsis No. 118—124.

General characters should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. gametes with a single cell-nucleus.
  2a. in isogamy:
    3a. planogametes (swarm-spores).
    3b. aplanogametes (without special external differentiation).
      4a. scalariform conjugation.
      4b. lateral conjugation.
  2b. in oogamy:
    3a. egg-cell.
      4a. oosphere; receptive spot.

    - 3b. male gamete.
      - 4a. swarm-spore.
      - 4b. spermatozoid.
      - 4c. spermatium.
      - 4d. without special external differentiation.
- 1b. coenogametes. See 1a.

No. 19. Guiding scheme for the description of gametangia.

For meaning of terms consult synopsis No. 126—129.

General characters should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. female gametangia.
  - 2a. oogonium.
    - 3a. number of egg-cells.
    - 3b. periplasm and episporium.
  - 2b. procarp.
    - 3a. uni- or pluricellular.
    - 3b. part containing the egg-cell or egg-cells.
      - 4a. carpogone.
      - 4b. ascogone.
    - 3c. trichogyne.
  - 2c. archegonium.
    - 3a. stalk.
    - 3b. archegonium proper.
      - 4a. venter.
        - 5a. wall.
        - 5b. contents.
          - 6a. oosphere.
          - 6b. ventral canal-cell.
      - 4b. neck.
        - 5a. wall, lid cells.
        - 5b. neck canal-cells.
- 1b. male gametangia (antheridia).
  - 2a. naked antheridia.
    - 3a. unilocular.
    - 3b. plurilocular.
    - 3c. dwarf males.
  - 2b. walled antheridia.
    - 3a. stalk.
    - 3b. antheridium proper.
      - 4a. wall, opening.
        - 5a. at the top.
        - 5b. with valves.
      - 4b. contents, spermatozoids.

No. 20. Guiding scheme for the description of the development of a zygote into spores.

For meaning of terms consult synopsis No. 130.

- 1a. zygote itself transformed into a spore.

  - 2a. zygospores.
  - 2b. oospores.
- 1b. zygote forming spores after a smaller or larger number of cell divisions.
  - 2a. number of cell divisions (sporophyte) restricted; spore developing into a body of relatively considerable dimensions.
    - 3a. carpospores. Sporogenous filaments (gonimoblasts), auxiliary cells, haploid or diploid.
    - 3b. ascospores. Ascogenous filaments, conjugated karyokinesis, asci, karyogamy, reduction division, free cell formation, number of spores.
    - 3c. basidiospores. Conjugation, fructification, conjugated karyokinesis (clamp-connections), basidia (number of cells, sterigmata), karyogamy, reduction division, number of spores.
    - 3d. spores produced by sporogonia.
  - 2b. number of cell divisions relatively larger, comprising the development of a predominating sporophyte; spore developing into a body of slight dimensions.
    - 3a. swarm-spores of *Laminariaceae.*
    - 3b. spores of isosporous *Pteridophyta.*
    - 3c. megaspores and microspores of heterosporous *Pteridophyta.*
    - 3d. embryo-sacs and pollen-cells.

No. 21. Guiding scheme for the description of sori and hymenia.

For meaning of terms consult synopsis No. 131—134.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. reproductive organs.
  - 2a. gemmae.
  - 2b. spores. See guiding scheme No. 13: spores and guiding scheme No. 14: conidiophores and basidia.
  - 2c. sporangia. See guiding scheme No. 15: unicellular sporangia and guiding scheme No. 16: pluricellular sporangium.
  - 2d. gametangia. See guiding scheme No. 19: gametangia.
- 1b. sterile additional organs.
  - 2a. receptacle.
  - 2c. indusium.
    - 3a. peltate indusium.
    - 3b. lip-shaped indusium.
    - 3c. false indusium.
  - 2c. paraphyses.
    - 3a. ordinary paraphyses.
    - 3b. cystids.
    - 3c. periphyses.
  - 2d. peridium.

No. 22. Guiding scheme for the determination of parts to be described with respect to their position in the groups of homologous and analogous organs.

For meaning of terms consult synopsis No. 72—76.

1a. thallome. See guiding schemes No. 25 and No. 26.
  2a. groups of analogous organs (metamorphoses).
    3a. vegetative organs.
      4a. organs of carbon assimilation.
      4b. organs of attachment to substrate and absorption of nutritious substances.
        5a. hapteres.
        5b. haustoria or suckers.
        5c. rhizoids and rhizines.
      4c. organs of storage of reserve materials.
        5a. thalloid tubers.
    3b. reproductive organs. See guiding schemes 11—16, 18, 19, 21.
1b. cormus.
  2a. groups of analogous organs (metamorphoses).
    3a. vegetative organs.
      4a. organs of carbon assimilation.
        5a. phylloclades or cladodes.
      4b. climbing organs.
        5a. hooks.
      4c. organs of storage of reserve materials and enabling to withstand injurious influences of climate.
        5a. subterranean.
          6a. rhizomes or root-stocks.
          6b. bulbs and bulbils.
          6c. cormoid tubers.
        5b. aerial.
          6a. succulent.
          6b. bulbs and bulbils.
      4d. spines or thorns.
    3b. reproductive organs. See guiding schemes No. 42, cormoid receptacle, No. 43, strobilus, No. 44, anthotaxy, No. 45 and 46, inflorescences, No. 47 and No. 48, flower, No. 49, pollen, No. 50, ovule, No. 51 and No. 52, fruit, No. 53, seed and moreover the guiding schemes belonging to the group of reproductive organs 11—16, 18, 19, 21.
1c. caulome.
  2a. groups of analogous organs (metamorphoses).
    3a. organs of carbon assimilation.
      4a. caulomes of succulent cormi. See 1b, 2a, 3a, 4c, 5b, 6a.
    3b. climbing organs.
      4a. twining organs.
      4b. tendrils.
        5a. adhesive discs.
    3c. organs of storage of reserve materials and enabling to withstand injurious influences of climate.
      4a. subterranean.
        5a. caudex or stock.
      4b. aerial.
        5a. woody stems of trees and shrubs.

        - 5b. caulomes of succulent cormi. See 1b, 2a, 3a, 4c, 5b, 6a.
    - 3d. spines or thorns.
- 1a. phyllome.
  - 2a. groups of analogous organs (metamorphoses).
    - 3a. organs of carbon assimilation.
      - 4a. foliage leaves.
      - 4b. phyllodes.
    - 3b. organs of nutrition in insectivorous plants.
      - 4a. pitchers and utricles.
    - 3c. climbing organs.
      - 4a. twining organs.
      - 4b. tendrils.
      - 4c. hooks.
    - 3d. organs of storage of reserve materials and enabling to withstand injurious influences of climate.
      - 4a. subterranean.
        - 5a. bulb scales.
      - 4b. aerial.
        - 5a. bulb scales.
        - 5b. succulent foliage leaves.
    - 3e. spines or thorns.
    - 3f. external glands.
      - 4a. nectaries.
- 1e. root.
  - 2a. groups of analogous organs (metamorphoses).
    - 3a. organs of carbon assimilation.
      - 4a. green, flattened aerial roots.
    - 3b. organs of attachment to substrate and absorption of nutritious substances.
      - 4a. ordinary roots.
      - 4b. hapteres.
      - 4c. haustoria or suckers.
    - 3c. climbing organs.
      - 4a. aerial climbing roots.
    - 3d. organs of storage of reserve materials and enabling to withstand injurious influences of climate.
      - 4a. subterranean.
        - 5a. root-tubers.
      - 4b. aerial.
        - 5a. root-tubers.
    - 3e. spines or thorns.
      - 4a. root-thorns or spiny roots.
- 1f. appendages of the external surface and the surfaces of internal cavities.
  - 2a. groups of analogous organs (metamorphoses).
    - 3a. vegetative organs.
      - 4a. organs of carbon assimilation.
        - 5a. paraphylls.
      - 4b. organs of nutrition in insectivorous plants.

            - 5a. bristle emergences.
        - 4c. organs of attachment to substrate and absorption of nutritious substances.
            - 5a. hapteres.
            - 5b. haustoria or suckers.
            - 5c. root-hairs, rhizoid and rhizines.
        - 4d. climbing organs.
            - 5a. hooks.
        - 4e. organs enabling to withstand injurious influences.
            - 5a. hairs of various kinds.
            - 5b. trichome or epidermal emissaries.
            - 5c. bristles.
            - 5d. scurves or scales and ramenta.
            - 5e. indusia of certain sori.
        - 4f. prickles.
        - 4g. external glands.
            - 5a. nectaries.
                - 6a. floral.
                - 6b. extra-floral.
            - 5b. excreting digestive fluids in insectivorous plants.
    - 3b. reproductive organs. See guiding scheme No. 21, sori and hymenia.

No. 23. Guiding scheme for the determination of disturbing and complicating phenomena in the course of development, during the division into organs, to be mentioned in their proper places.

For meaning of terms consult synopsis No. 68 and 135—139.

- 1a. displacement.
- 1b. concrescence, adnation, concretion, coalescence, symphysis, connation.
- 1c. doubling, duplication, collateral chorisis, dédoublement.
- 1d. abortion, atrophy.

No. 24. Guiding scheme for the organographical description of appendages of the surface.

For meaning of terms consult synopsis No. 447—450.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. papillae.
    - 2a. ordinary papillae.
    - 2b. stigmatic papillae.
    - 2c. capitate papillae.
- 1b. hairs (pilose).
    - 2a. ordinary hairs (if branched see guiding scheme No. 6; branch-systems).
        - 3a. pubescent or downy.
        - 3b. shaggy.
        - 3c. hirsute.

        - 3d. woolly.
        - 3e. tomentose.
    - 2b. balance hairs.
    - 2c. stellate hairs.
    - 2d. clinging hairs.
    - 2e. collecting or brush-like hairs of style.
    - 2f. stings or stinging hairs.
    - 2g. capitate hairs.
        - 3a. ordinary capitate hairs.
            - 4e. stalk.
            - 4b. head.
        - 3b. glandular capitate hairs.
            - 4a. stalk.
            - 4b. head.
    - 2h. root-hairs.
        - 3a. rhizoids.
        - 3b. rhizines.
- 1c. haptere-appendages.
- 1d. haustorial appendages.
- 1e. epidermal or trichome emissaries.
- 1f. bristles.
- 1g. prickles.
- 1h. scurves or scales.
    - 2a. ordinary scurves.
    - 2b. ramenta.
- 1i. paraphylls.
- 1j. indusia of sori.
- 1k. paraphyses (unbranched or branched).
    - 2a. cystids.
    - 2b. periphyses.

Group III. Special Organography.

A. Thallome.

No. 25. Guiding scheme for the determination and description of special forms of thallomes. In order to make complete descriptions it will be often necessary to consult moreover guiding scheme No. 26, for the general description of a thallome.

For meaning of terms consult synopsis No. 141—173.

General characters (shape, dimensions, chemical composition, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. thallomes (including swarm spores and spermatozoids) with locomotion.
    - 2a. amoeboid creeping movements.
        - 3a. pseudopodia.
    - 2b. swimming movements.
        - 3a. cilia and flagella; undulating membranes.

      - 4a. monotrichous cells.
      - 4b. ditrichous cells.
        - 5a. monopolar.
        - 5b. bipolar.
      - 4c. polytrichous or polyciliate cells.
        - 5a. lophotrichous cells.
          - 6a. monopolar.
            - 7a. at one of the ends.
            - 7b. laterally.
          - 6b. bipolar.
        - 5b. peritrichous cells.
    - 3b. eye spot (stigma).
- 1b. unicellular thallomes with cell walls consisting of two or more separate parts (theca).
  - 2a. valves or halves.
    - 3a. epitheca.
      - 4a. epivalva.
      - 4b. epipleura.
      - 4c. copula.
    - 3b. hypotheca.
      - 4a. hypovalva.
      - 4b. hypopleura.
      - 4c. copula.
- 1c. special forms in the group of *Bacteria*.
  - 2a. shape of unicellular forms.
    - 3a. coccus, micrococcus, macrococcus.
    - 3b. bacterium, bacillus.
    - 3c. vibrio.
    - 3d. spirillum.
    - 3e. spirochaete.
  - 2b. number and arrangement of cells in pluricellular forms.
    - 3a. cell division in a single direction.
      - 4a. diplococcus.
      - 4b. numerous cells, filaments.
        - 5a. without a sheath.
          - 6a. streptococcus.
        - 5b. with a sheath.
          - 6a. leptothrix.
          - 6b. cladothrix.
    - 3b. cell division in two directions at right angles.
      - 4a. tetracoccus (merismopedia).
      - 4b. flat disks, up to sixteen cocci.
    - 3c. cell division in three directions at right angles.
      - 4a. sarcine.
    - 3d. cell division in several irregular directions.
      - 4a. staphylococcus.
  - 2c. unicellular forms with endospores.
    - 3a. clostridium.
    - 3b. plectridium.

- 1d. thallomes which may be considered colonies.
  - 2a. zoogloea.
- 1e. compound thallomes or thallomes in the form of consortia.
  - 2a. homoiomerous or unstratified thallus.
  - 2b. heteromerous or stratified thallus.
    - 3a. epidermis.
    - 3b. rind.
    - 3c. gonidial layer.
    - 3d. medullary tissue.
- 1f. thalloid gametophytes.
  - 2a. ordinary.
  - 2b. prothallium.
- 1g. more or less filamentous parts formed during the first developmental stages of germinating spores.
  - 2a. protonema.
    - 3a. branched. See guiding scheme No. 6.
    - 3b. unbranched.
    - 3c. plate-like.
    - 3d. reduced to germ-tube.
  - 2b. suspensor.
  - 2c. promycelium.
- 1h. thalloid sporophyte.
  - 2a. ordinary.
  - 2b. sporogonium. See guiding scheme No. 17.
- 1i. sclerotia.
  - 2a. ramification, see guiding scheme No. 6.
- 1j. fructifications.
  - 2a. thalloid gemmiferous receptacles or gemma cups.
    - 3a. wall of the cup.
    - 3b. gemmae.
    - 3c. paraphyses.
  - 2b. coremia.
  - 2c. spore-beds.
  - 2d. fructifications arising from plasmodia. Aethalia and simpler forms.
    - 3a. stalk.
    - 3b. capsule.
      - 4a. peridium.
      - 4b. spores.
      - 4c. capillitium.
      - 4d. cellular elaters.
  - 2e. fructifications containing conceptacula.
    - 3a. conceptacles.
      - 4a. distribution and shape.
      - 4b. hymenium.
        - 5a. antheridia and oogonia.
        - 5b. paraphyses.
  - 2f. cystocarps.

  - 3a. distribution and shape.
  - 3b. pericarp (peridium).
  - 3c. carpospores.
- 2g. globules.
  - 3a. distribution.
  - 3b. stalk cell.
    - 4a. flat cell at its top.
  - 3c. shield.
  - 3d. manubria.
  - 3e. head-cells.
  - 3f. secondary head-cells.
  - 3g. sori of antheridia. See guiding scheme No. 19.
- 2h. nucules or spore-buds.
  - 3a. distribution.
  - 3b. stalk cell.
  - 3c. peridium or sporostegium.
    - 4a. coronula.
  - 3d. oogonium. See guiding scheme No. 19.
    - 4a. turning cells.
- 2i. apothecia.
  - 3a. peridium.
  - 3b. hymenium.
    - 4a. asci.
    - 4b. paraphyses.
- 2k. perithecia.
  - 3a. distribution (stroma).
  - 3b. peridium.
  - 3c. hymenium.
    - 4a. asci.
    - 4b. paraphyses, periphyses.
- 2l. aecidia.
  - 3a. peridium.
  - 3b. hymenium, spores.
- 2m. podetia.
  - 3a. apothecia. See 1j, 2i.
- 2n. fructifications of the higher *Fungi*, *Hymenomycetes* and *Gasteromycetes*.
  - 3a. crustaceous.
    - 4a. hymenium.
      - 5a. basidia.
      - 5b. paraphyses.
  - 3b. fruticose. See 3a.
  - 3c. capitate fructifications.
    - 4a. peridium, volva or velum universale.
      - 5a. sheath.
      - 5b. scales on the pileus.
    - 4b. capitate fructifications proper.
      - 5a. stalk.
      - 5b. pileus.

            - 6a. gleba.
            - 6b. velum partiale.
                - 7a. annulus.
                - 7b. cortina.
            - 6c. parts bearing the hymenium.
                - 7a. conical projections.
                - 7b. tubular projections.
                - 7c. lamellae or gills (trama).
            - 6d. hymenium.
                - 7a. basidia.
                - 7b. paraphyses.
                - 7c. cystids.
- 2o. spermogonia, pycnidia.
    - 3a. distribution (stroma).
    - 3b. gametophores or conidiophores.
    - 3c. spermatia and pycnospores.
- 2p. marsupia.
    - 3a. distribution.
- 2q. thalloid male and female receptacles (*Marchantia*).
    - 3a. stalk.
    - 3b. disciform part.
        - 4a. male disc.
            - 5a. antheridia. See guiding scheme No. 19.
        - 4b. female disc.
            - 5a. involucre.
            - 5b. archegonia. See guiding scheme No. 19.

No. 26. General guiding scheme for the description of a thallome.

For meaning of terms consult synopsis No. 140.

General characters (shape, dimensions, chemical composition, colour, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. unicellular, when no special term is available. See scheme No. 61.
- 1b. filamentous.
    - 2a. unicellular. See scheme No. 61.
    - 2b. multicellular and uniseriate.
        - 3a. ramification. See guiding scheme No. 6.
        - 3b. hapterae, rhizoids.
        - 3c. heterocysts.
- 1c. thallus.
    - 2a. foliaceous.
        - 3a. ramification. See guiding scheme No. 6.
        - 3b. hapteres.
        - 3c. root-hairs, rhizines and other appendages of the surface.
    - 2b. fructicose. See 2a.
    - 2c. crustaceous. See 2a.
    - 2d. tuberous. See 2a.
- 1d. mycelium.

  - 2a. ramification. See guiding scheme No. 6.
- 1e. plasmodium.
  - 2a. ramification. See guiding scheme No. 6.

B. Cormus.

No. 27. Guiding scheme for determining the succession of cormi in cormoid systems.

For meaning of terms consult synopsis No. 251—252.

For the construction of diagrams consult synopsis No. 751 and Plates III—VII.

- 1a. kind of succession of cormi.
  - 2a. uniaxial or haplocaulescent.
    - 3a. homogeneous individualization of cormi.
    - 3b. heterogeneous individualization of cormi.
  - 2b. biaxial or diplocaulescent.
    - 3a. homogeneous individualization of cormi.
    - 3b. heterogeneous individualization of cormi.
    - 3c. coordination.
    - 3d. subordination.
  - 2c. triaxial or triplocaulescent. See 2b.
  - 2d. quadriaxial, quinquaxial, etc. up to pluriaxial or tetraplocaulescent, pentaplocaulescent, etc. up to pleiocaulescent. See 2b.
- 1b. succession of cormi formula.

No. 28. Introductory guiding scheme for the description of the spatial relations in a cormoid system.

- 1a. succession of cormi leading to the construction of a succession of cormi formula. See guiding scheme No. 27.
- 1b. branching. See guiding scheme No. 6.
- 1c. relations between lateral cormus-individuals (or cormoid buds) and certain phyllomes belonging to their podia. See guiding scheme No. 29.
- 1d. relations between cotyledons and the symmetry of ovule and seed.
- 1e. relations between the prophylls of a branch and its podium. See guiding scheme No. 30.
- 1f. phyllotaxy. See guiding scheme No. 31.
- 1g. the mode of junction of the higher placed phyllomes to the prophylls of the same lateral branch. See guiding scheme No. 32.
- 1h. relations between the spiral phyllotaxy of a branch and the same of its podium. See guiding scheme No. 33.
- 1i. aestivation and plication. See guiding scheme No. 34.
- 1k. vernation. See guiding scheme No. 35.

No. 29. Guiding scheme for determining the spatial relations between lateral cormus-individuals (or cormoid buds) and certain phyllomes belonging to their podia.

For meaning of terms consult synopsis No. 266 and 267.

- 1a. axillary bud or branch and subtending phyllome.
  - 2a. serial buds.

    3a. descending.
    3b. ascending.
  2b. collateral buds.
  2c. intrapetiolar bud.
  2d. bud placed on the caulome somewhat above the subtending phyllome.
  2e. bud placed on the upper side of the petiole.
1b. cases not designated by special terms.
  2a. dichotomy, angular leaf.
  2b. bud placed below the base of a phyllome.
    3a. in the median plane.
    3b. obliquely.
  2c. bud placed at the side of à leaf.
    3a. on the level of the leaf.
    3b. obliquely below.
    3c. obliquely above.
  2d. bud placed on the underside of the petiole.

No. 30. Guiding scheme for determining the spatial relations between the prophylls of a branch and its podium.

For meaning of terms consult synopsis No. 266 and 268.

1a. a single prophyll, called bracteole in the vicinity of a flower.
  2a. placed adaxially.
  2b. placed otherwise.
1b. two prophylls, called bracteoles in the vicinity of a flower.
  2a. position.
    3a. placed transversely.
    3b. placed otherwise.
  2b. reciprocal age.
    3a. of the same age.
    3b. of different ages.
      4a. prophyll or bracteole α.
      4b. prophyll or bracteole β.

No. 31. Guiding scheme for the determination of phyllotaxy.

For meaning of terms consult synopsis No. 255—256.

For the construction of phyllotactical diagrams consult synopsis No. 743—751 and Plates I—VII.

1a. spiral or scattered arrangement.
  2a. distichous arrangement.
  2b. tristichous arrangement.
  2c. quincuncial arrangement.
1b. jugate arrangement.
1c. whorled or verticillate arrangement.
  2a. homomerous or heteromerous whorls.
  2b. dimerous, trimerous, etc. whorls.
  2c. alternation of members.
    3a. decussate arrangement.
      4a. Caryophyllaceous arrangement.

      - 4b. Fraxinus arrangement.
  - 2d. superposition or opposition of members.

No. 32. Guiding scheme for determining the mode of junction between the higher placed phyllomes and the prophylls of the same lateral branch.

For meaning of terms consult synopsis No. 266, 270 and 271.

- 1a. prophylls wanting.
  - 2a. typically wanting.
  - 2b. wanting by abortion.
- 1b. prophylls present.
  - 2a. spiral phyllotaxy.
    - 3a. a single prophyll.
      - 4a. divergence $^1/_3$.
      - 4b. divergence $^2/_5$.
    - 3b. two prophylls.
      - 4a. divergence $^1/_3$.
      - 4b. divergence $^2/_5$.
    - 3c. direction of junction.
      - 4a. emprosthodromous cormus-individual (flower).
      - 4b. opisthodromous cormus-individual (flower).
  - 2c. cyclic phyllotaxy.
    - 3a. a single adaxial prophyll.
      - 4a. dimerous whorls.
      - 4b. trimerous whorls.
    - 3b. two transversely placed prophylls.
      - 4a. dimerous whorls.
      - 4b. trimerous whorls.
      - 4c. tetramerous whorls.
        - 5a. first whorl in a median-transverse cross.
        - 5b. first whorl in a diagonal cross.
          - 6a. true tetramerous whorl.
          - 6b. arising by abortion out of a pentamerous whorl.
      - 4d. pentamerous whorls.

No. 33. Guiding scheme for determining the spatial relations between the spiral phyllotaxy of branches and that of their podium.

For meaning of terms consult synopsis No. 266 and 272.

- 1a. homodromous genetic spiral in the phyllotaxy of the branches.
- 1b. antidromous genetic spiral in the phyllotaxy of the branches.
- 1c. poecilodromy in the phyllotaxy of the branches.

No. 34. Guiding scheme for the description and determination of aestivation and plication.

For meaning of terms consult synopsis No. 253 and 258—265.

- 1a. aestivation.
  - 2a. transverse.
    - 3a. open or indeterminate.
    - 3b. closed.

4a. valvular (valvate phyllomes). In combination with vernation and eventually concrescence:

- 5a. valvular-induplicate (valvate-induplicate phyllomes).
- 5b. valvular-reduplicate (valvate-reduplicate phyllomes).
- 5c. valvular involute (valvate-involute phyllomes).

4b. imbricative (imbricate phyllomes).

- 5a. divergence of eventual spiral arrangement.
- 5b. quincuncial ($^2/_5$).
- 5c. cochlear.
- 5d. contorted or twisted.
  - 6a. dextrorse.
  - 6b. sinistrorse.
- 5e. equitant.
  - 6a. equitant-triquetrous.
- 5f. vexillary or descendant.
- 5g. ascendant.

- 2b. longitudinal.
  - 3a. imbricative (imbricate phyllomes).
    - 4a. succubous phyllomes.
      - 5a. apically.
      - 5b. laterally.
    - 4b. incubous phyllomes.
      - 5a. apically.
      - 5b. laterally.
- 1b. plications or plaits.
  - 2a. outwardly salient.
  - 2b. internal.
  - 2c. straight.
  - 2d. supervolute.
  - 2e. spirally twisted.

No. 35. Guiding scheme for the description of vernation.

For meaning of terms consult synopsis No. 253 and 257.

- 1a. plain.
- 1b. folded.
  - 2a. conduplicate.
  - 2b. plicate or plaited.
  - 2c. induplicate.
  - 2d. reduplicate.
  - 2e. corrugate, wrinkled or crumpled.
  - 2f. reclinate, inclinate, replicate or inflexed.
- 1c. rolled up.
  - 2a. involute.
  - 2b. revolute.
  - 2c. convolute or supervolute.
  - 2d. circinate or circinal.
    - 3a. vernatio retrorsum circinata.

No. 36. Guiding scheme for the determination of specially differentiated cormi. In making description the general guiding scheme No.

37 and moreover guiding scheme No. 27 for the succession of cormi should be consulted.

1a. vegetative cormi.
  2a. leafy or foliage cormi, cormoid systems, cormus-individuals and periodic shoots.
  2b. suckers or gourmandisers.
  2c. elongated and short or dwarf cormus-individuals.
  2d. cormoid rhizomes.
  2e. cladodes, phylloclades or cladophylls.
  2f. radical rosette.
  2g. rhizophores.
  2h. tendrillar cormi or cormoid tendrils.
  2i. cormoid spines.
  2k. cormoid buds. See guiding scheme No. 38.
  2l. bulbs. See guiding scheme No. 39.
  2m. cormoid tubers. See guiding scheme No. 40.
1b. fructifications.
  2a. stolons or runners. See guiding scheme No. 41.
  2b. cormoid receptacles. See guiding scheme No. 42.
  2c. strobili. See guiding scheme No. 43.
  2d. floral cormi.
    3a. inflorescence. See guiding schemes No. 45 and No. 46.
    3b. flower. See guiding schemes No. 47 and 48.
    3c. fruit and seed. See guiding schemes No. 51, 52, 53.

No. 37. General guiding scheme for the description of the vegetative region of a cormus-individual, a periodic shoot, a cormoid system and stolons or runners, although the latter belong to the region of fructifications (asexual).

For meaning of terms consult synopsis No. 243—245.

1a. spatial relations. See guiding scheme No. 28.
1b. description of the several cormus-individuals or periodic shoots.
  2a. the cataphyllary region.
    3a. extension.
      4a. wanting.
      4b. limited to the base.
      4c. extending over a more considerable part of the base.
      4d. extending over the whole cormus-individual.
    3b. cotyledons. See guiding scheme No. 53, seed.
    3c. caulome. See guiding schemes No. 54 and 55.
    3d. prophylls.
      4a. a single one.
      4b. two.
    3e. phyllomes. See guiding schemes No. 56 and 57.
  2b. middle region.
    3a. caulome. See guiding scheme No. 54 and 55.
    3b. phyllomes. See guiding schemes No. 56 and 57.

No. 38. Guiding scheme for the determination and description of a cormoid bud.

For meaning of terms consult synopsis No. 273 and 281—284.

1a. determination.
  2a. position.
    3a. terminal.
    3b. lateral.
    3c. adventitious.
  2b. contents.
    3a. leaf bud.
    3b. floral bud.
    3c. mixed bud.
  2c. investment.
    3a. naked bud.
    3b. scaly bud.
      4a. perule consisting of bud scales.
1b. description. For the detailed description of the parts constituting the bud the following guiding schemes should be consulted:
  2a. guiding scheme No. 27 for determining the order of sequence of cormus-individuals.
  2b. guiding scheme No. 37 for the description of the vegetative region of cormus-individuals or cormoid systems.
  2c. phase of development. See guiding scheme No. 10.

No. 39. Guiding scheme for the determination and description of a bulb.

For meaning of terms consult synopsis No. 273 and 285—289.

1a. determination.
  2a. place of occurrence.
    3a. subterranean bulbs.
    3b. bulblets or aerial bulbs.
  2b. investment.
    3a. tunicated bulbs.
    3b. naked bulbs.
1b. description.
  2a. monopodial bulb.
    3a. number of annual shoots counted, if possible from the germination of the seed.
    3b. description of each separate annual shoot.
      4a. discal part. See guiding scheme No. 55, caulome.
      4b. bulb-scales. See guiding scheme No. 57, phyllome.
      4c. bud of the bulb. See guiding scheme No. 38.
      4d. bulbules.
      4e. aerial parts arising from the bulb at their proper time.
        5a. vegetative region. See guiding scheme No. 37.
        5b. region of fructification developed from a lateral bud. Phase of development. See guiding scheme No. 10.
      4f. fibrous roots growing from the bulb at their proper time. See guiding scheme No. 60.
  2b. sympodial bulb.

3a. number of cormus-individuals counted, if possible from the germination of the seed.
- 3b. description of each separate cormus-individual.
  - 4a. discal part. See guiding scheme No. 55, caulome.
  - 4b. bulb-scales. See guiding scheme No. 57, phyllome.
  - 4c. aerial parts arising from the bulb at their proper time.
    - 5a. vegetative region. See guiding scheme No. 37.
    - 5b. region of fructification. Phase of development. See guiding scheme No. 10.
  - 4d. bud of the bulb. See guiding scheme No. 38.
  - 4e. bulbules.
  - 4f. fibrous roots growing from the bulb at their proper time. See guiding scheme No. 60.

2c. mono-sympodial bulb. See 1b, 2a, and 2b.

No. 40. Guiding scheme for the determination and description of a cormoid tuber.

For meaning of terms consult synopsis No. 273 and 290—295.

- 1a. determination.
  - 2a. place of occurrence.
    - 3a. subterranean cormoid tuber.
    - 3b. aerial cormoid tuber.
  - 2b. investment.
    - 3a. tunicated cormoid tuber.
    - 3b. naked cormoid tuber.
    - 3c. pseudobulb.
- 1b. description.
  - 2a. naked cormoid tuber.
    - 3a. caulome part. See guiding scheme No. 55, caulome.
    - 3b. scales. See guiding scheme No. 57, phyllome.
    - 3c. buds. See guiding scheme No. 38, bud.
  - 2b. tunicated cormoid tuber.
    - 3a. sympodial cormoid tuber.
      - 4a. number of cormus-individuals.
      - 4b. description of each separate cormus-individual.
        - 5a. caulome part. See guiding scheme No. 55, caulome.
        - 5b. scales of the tuber. See guiding scheme No. 57, phyllome.
        - 5c. aerial parts arising from the tuber at their proper time.
          - 6a. vegetative region. See guiding scheme No. 37.
          - 6b. region of fructifications. Phase of development. See guiding scheme 10.
        - 5d. bud of the tuber. See guiding scheme No. 38.
        - 5e. subordinate buds.
        - 5f. fibrous roots growing from the tuber at their proper time. See guiding scheme No. 60.
    - 3b. mono-sympodial cormoid tuber.
      - 4a. number of annual shoots or cormus-individuals.
      - 4b. description of the above. See 3a, 4b.

No. 41. Guiding scheme for the determination and description of stolons or runners.

For meaning of terms consult synopsis No. 296 and 297.

1a. determination.
  2a. surface stolons, surface runners or flagella.
    3a. leaf-runners.
    3b. inflorescence runners.
  2b. submerged runners.
  2c. subterranean or underground stolons, runners or offsets.
1b. description.

For making a detailed description consult guiding scheme No. 37, vegetative region of cormus.

No. 42. Guiding scheme for the description of a cormoid receptacle.

For meaning of terms consult synopsis No. 247, 248, 296 and 298.

1a. spatial relations. See guiding scheme No. 28.
1b. perichaetium. See guiding scheme No. 57, phyllome.
1c. gemmae, gametangia. See guiding scheme No. 19.

No. 43. Guiding scheme for the description of a strobilus.

For meaning of terms consult synopsis No. 296 and 299 and moreover No. 247, 248.

1a. spatial relations. See guiding scheme No. 28.
1b. region of enveloping phyllomes. See guiding scheme No. 57, phyllome.
  2a. annulus of *Equisetum*.
1c. region of sporophylls.
  2a. isosporophylls. If leaf scales see guiding scheme No. 57, phyllome.
    3a. sporangia. See guiding scheme No. 16.
  2b. microsporophylls.
    3a. leaf scales. See guiding scheme No. 57.
      4a. microsporangia. See guiding scheme No. 16.
    3b. stamens. See guiding scheme No. 47, flower, 1c, 2c.
  2c. mega- or macrosporophylls.
    3a. simple leaf scales. See guiding scheme No. 57.
      4a. macrosporangia. See guiding scheme No. 16.
      4b. ovules. See guiding scheme No. 50.
    3b. double leaf scales.
      4a. bract scale or tegumentary scale. See guiding scheme No. 57.
      4b. ovuliferous or seminiferous scale. See guiding scheme No. 57.
      4c. ovules. See guiding scheme No. 50.
  2d. sterile bracts between the sporophylls. See guiding scheme No. 57.
    3a. interseminal scales.

No. 44. Guiding scheme for determining the kind of anthotaxy.

For meaning of terms consult synopsis No. 300—303.

1a. the one-flowered plant.
1b. terminal flowers in cormus-individuals exhibiting also a cataphyllary and a middle region.
1c. scattered or solitary flowers.
1d. the inflorescence. See guiding scheme No. 45.
1e. cauliflory.

For the description of the above cases see guiding scheme No. 46.

No. 45. Guiding scheme for the determination of special kinds of inflorescences. In making descriptions the general guiding scheme No. 46 should always be consulted.

For meaning of terms consult synopsis No. 307—316.

1a. general shape.
  2a. panicle.
  2b. corymb.
  2c. anthela.
  2d. glomerule.
  2e. false whorl.
1b. deciduous character.
  2a. catkin.
1c. succulent consistency of the peduncle.
  2a. spadix.
  2b. coenanthium.
1d. mode of ramification.
  2a. homotactical.
    3a. botryose or racemose.
      4a. simple.
        5a. raceme.
          6a. simple corymb.
        5b. spike.
          6a. spikelets.
          6b. spadix.
          6c. catkin.
        5c. umbel.
          6a. superposed umbel.
        5d. head.
          6a. homogamous.
          6b. heterogamous.
            7a. disc-florets.
            7b. ray-florets.
      4b. compound.
        5a. uniformly reiterating.
          6a. compound, bi-, tri-, etc. compound raceme with racemules.
          6b. compound, bi-, tri-, etc. compound spike.
          6c. compound umbel.
            7a. universal umbel.
            7b. partial umbels or umbellules.
          6d. compound head.

- 5b. mixed.
- 3b. cymose.
  - 4a. pleiochasium.
    - 5a. trichasium.
    - 5b. cyathium.
  - 4b. dichasium.
    - 5a. with screw-tendency.
    - 5b. with cincinnus-tendency.
  - 4c. monochasium.
    - 5a. sickle or drepanium.
    - 5b. fan or rhipidium.
    - 5c. screw or bostryx.
      - 6a. bracteole α fertile.
        - 7a. flowers emprosthodromous.
        - 7b. flowers opisthodromous.
      - 6b. bracteole β fertile.
        - 7a. flowers emprosthodromous.
        - 7b. flowers opisthodromous.
    - 5d. cincinnus.
      - 6a. bracteole α fertile.
        - 7a. flowers emprosthodromous.
        - 7b. flowers opisthodromous.
      - 6b. bracteole β fertile.
        - 7a. flowers emprosthodromous.
        - 7b. flowers opisthodromous.
- 2b. heterotactical.

No. 46. General guiding scheme for the description of an inflorescence.

For meaning of terms consult synopsis No. 304—306.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding scheme No. 7 and No. 8.

- 1a. spatial relations in so far as they have not been already used in the determination of the kind of inflorescence (guiding scheme No. 45).
- 1b. disposition and mutual arrangement.
  - 2a. terminal.
  - 2b. lateral.
- 1c. scape.
- 1d. flower-stalk.
  - 2a. sessile flower.
  - 2b. pedicel.
- 1e. peduncle.
  - 2a. general peduncle, primary peduncle, rhachis, receptacle of the inflorescence.
  - 2b. branches of the first, second, etc. order.
    - 3a. pleiocaulescent cormoid system.
    - 3b. haplocaulescent cormoid system.

1f. phyllomes of the bracteal or hypsophyllary region.
  2a. spathe.
    3a. spathilla.
  2b. bracts.
    3a. involucre.
      4a. universal.
      4b. partial or involucellum.
    3b. glumes.
    3c. paleae corresponding to subtending phyllomes of flowers, chaffs, palets or pales.
      4a. palea inferior.
    3d. utricle.
  2c. bracteoles.
    3a. subtending phyllomes, representing bracts.
    3b. sterile.
    3c. number.
      4a. a single one.
        5a. palea superior.
      4b. two.
        5a. bracteole α.
        5b. bracteole β.
1g. flowers of florets. See guiding scheme No. 47.
1h. special inflorescences. To be determined with the help of guiding scheme No. 45 and afterwards described with the help of the present guiding scheme.

No. 47. Guiding scheme for the description of a flower.

For meaning of terms consult synopsis No. 317—374.

General characters (shape, dimensions, chemical composition, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding scheme No. 7 and No. 8.

For the construction of floral diagrams consult synopsis No. 743—749 and Plate I and IV.

1a. floral formula.
1b. spatial relations, to be examined for obtaining a preliminary survey; the results to be used in the description in their proper places. See guiding scheme No. 28.
  2a. phyllotaxy. See guiding scheme No. 31.

  In describing the androecium the following special terms may be used:
      3a. episepalous stamens.
      3b. epipetalous stamens.
      3c. epitepalous stamens.
  2b. aestivation. See guiding scheme No. 34.
  2c. vernation. See guiding scheme No. 35.
1c. description of the several parts of the flower.
  2a. the floral receptacle.
    3a. parts of the receptacle.

      - 4a. hypanthium.
      - 4b. anthophore.
      - 4c. androphore.
      - 4d. gynophore.
    - 3b. effigurations of the receptacle.
      - 4a. disc.
        - 5a. extrastaminal.
          - 6a. between stamens and corolla.
          - 6b. between corolla and calyx.
        - 5b. intrastaminal.
        - 5c. central.
      - 4b. discal glands.
      - 4c. discal scales.
    - 3c. nectaries of the receptacle.
  - 2b. perianth.
    - 3a. represented by appendages of the surface.
      - 4a. pilose.
      - 4b. pappus.
    - 3b. formed by phyllomes.
      - 4a. homoiochlamydeous perianth.
        - 5a. perigon.
      - 4b. heterochlamydeous perianth.
        - 5a. calyx.
          - 6a. epicalyx.
        - 5b. corolla.
        - 5c. nectaries.
        - 5d. rudimentary scales.
        - 5e. lodicules.
      - 4c. grade of adnation of the members.
        - 5a. polyphyllous.
          - 6a. polysepalous calyx.
            - 7a. number of the members.
            - 7b. claw.
            - 7c. limb.
          - 6b. polypetalous corolla.
            - 7a. number of the members.
            - 7b. claw.
            - 7c. limb.
          - 6c. polytepalous perigon.
            - 7a. number of the members.
            - 7b. claw.
            - 7c. limb.
        - 5b. gamophyllous.
          - 6a. gamosepalous calyx.
            - 7a. number of the members united together.
            - 7b. lobed limb.
            - 7c. split limb.
            - 7d. parted limb.
          - 6b. gamopetalous or sympetalous corolla.

7a. number of the members united together.
7b. lobed limb.
7c. split limb.
7d. parted limb.
6c. gamotepalous or syntepalous perigon.
7a. number of the members united together.
7b. lobed limb.
7c. split limb.
7d. parted limb.
4d. shape of the perianth (calyx, corolla or perigon).
5a. actinomorphous.
6a. rotate or wheel-shaped.
6b. tubular.
6c. salver-shaped.
6d. pitcher-shaped.
6e. funnel-shaped.
6f. bell-shaped.
5b. zygomorphous or dorsiventral.
6a. calcarate or spurred.
6b. labiate or ringent.
7a. upper lip.
7b. lower lip.
6c. personate or masked.
7a. upper lip.
7b. lower lip and palate.
6d. papilionaceous or butterfly-shaped.
7a. keel or carina.
7b. leeboards (wings, alae).
7c. vexillum or standard.
6e. ligulate or strap-shaped.
3c. effigurations of the perianth.
3d. nectaries of the perianth.
2c. androecium.
3a. stamens.
4a. number of stamens, up to many or indefinite; exact number to be determined.
4b. insertion of stamens.
5a. hypogynous.
5b. perigynous.
5c. epigynous.
4c. number of whorls of stamens.
5a. haplostemonous androecium.
5b. diplostemonous androecium.
6a. obdiplostemonous androecium.
5c. increased number of whorls.
4d. unequal length of stamens.
5a. didynamous.
5b. tetradynamous.
4e. coherence of stamens.

- 5a. of filaments.
  - 6a. monadelphous stamens.
  - 6b. diadelphous stamens.
  - 6c. polyadelphous stamens.
- 5b. of anthers: syngenesious stamens.

- 4f. parts of stamens.
  - 5a. filament.
    - 6a. gynostemium.
    - 6b. ordinary filament.
  - 5b. anthers.
    - 6a. parts of anthers.
      - 7a. connective.
      - 7b. thecae and pollen-sacs of peltate stamens.
        - 8a. number.
        - 8b. number of loculi in thecae.
      - 7c. pollen. See guiding scheme No. 49.
    - 6b. disposition of anthers.
      - 7a. innate anthers.
      - 7b. adnate anthers.
      - 7c. versatile anthers.
    - 6c. dehiscence of thecae.
      - 7a. with a longitudinal slit.
        - 8a. introrse.
        - 8b. lateral or marginal.
        - 8c. extrorse.
      - 7b. with a pore.
      - 7c. by uplifted valves.

- 3b. staminodes. See 3a.

- 2d. gynoecium.
  - 3a. pistils.
    - 4a. number of pistils.
    - 4b. number of carpids forming a pistil.
      - 5a. simple.
      - 5b. compound, number to be mentioned.
    - 4c. arrangement of carpids.
      - 5a. apocarpous gynoecium.
        - 6a. ventral suture.
        - 6b. dorsal suture.
      - 5b. syncarpous gynoecium.
    - 4d. parts of pistil.
      - 5a. ovary.
        - 6a. position.
          - 7a. superior (hypogynous and perigynous insertion, see S. No. 344).
          - 7b. inferior (epigynous insertion, see S. No. 344).
        - 6b. number of cavities.
          - 7a. unilocular or one-celled and mode of its formation.
          - 7b. plurilocular or several-celled and mode of vernation.
            - 8a. bilocular or two-celled.

        - 8b. trilocular or three-celled.
        - 8c. multilocular or many-celled.
    - 6c. constituting parts.
      - 7a. wall.
      - 7b. dissepiments.
        - 8a. true.
        - 8b. false.
        - 8c. complete.
        - 8d. incomplete.
      - 7c. placentae (placentation).
        - 8a. parietal.
        - 8b. axile.
        - 8c. central.
      - 7d. ovules. See guiding scheme No. 50.
  - 5b. style.
    - 6a. stylopode.
    - 6b. number of styles.
    - 6c. stylar canal.
      - 7a. hollow.
      - 7b. conducting or conductive tissue.
  - 5c. stigma.
    - 6a. number on each style.
  - 5d. nectaries.
- 3b. carpodes. See 3a.

No. 48. Guiding scheme for the determination of special forms of flowers, the same flower often belonging to several of these forms. In making descriptions the general guiding scheme No. 47 should always be consulted.

For meaning of terms consult synopsis No. 375—380.

- 1a. occurrence of floral belts.
  - 2a. complete.
  - 2b. incomplete.
    - 3a. with a perigon.
    - 3b. naked.
- 1b. occurrence, arrangement and maturation of the two sexes. See guiding scheme No. 4, excepting 1b, 2b.
- 1c. general shape.
  - 2a. actinomorphous, radially symmetrical or regular.
  - 2b. zygomorphous, dorsiventral or symmetrical.
    - 3a. medianly dorsiventral or medianly zygomorphous.
    - 3b. transversely dorsiventral or transversely zygomorphous.
    - 3c. obliquely dorsiventral or obliquely zygomorphous. Resupination, reversion or inversion.
  - 2c. asymmetrical. In this case the symmetry of the separate floral belts is to be indicated.
- 1d. shape of receptacle and position of pistils.
  - 2a. hypogynous.
  - 2b. perigynous. Cupula.

    - 2c. epigynous.
- 1e. phyllotaxy.
    - 2a. acyclic.
    - 2b. cyclic.
        - 3a. number of cycles (tetracyclic, pentacyclic, etc.)
    - 2c. hemicyclic.

The above part of this guiding scheme ought to be consulted before describing any flower, but there is a certain number of particular forms and the principal of these, dealt with in the Synopsis, are mentioned below:

- 1f. poly- or choripetalous and gamo- or sympetalous.
- 1g. labiate, personate, papilionaceous and ligulate.
- 1h. gynandrous.
- 1i. polyandrous.
- 1k. thalamiflorous, calyciflorous and corolliflorous.
- 1l. haplostemonous, diplostemonous and obdiplostemonous.
- 1m. apocarpous and syncarpous.
- 1n. peloria or peloric flower.
    - 2a. parts of normal flower corresponding to those of the peloria.
    - 2b. terminal.
    - 2c. lateral.
- 1o. flowers with a labellum. Resupination, reversion or inversion.

No. 49. Guiding scheme for the organographical description of pollen, immediately before and after pollination.

For anatomical characters see guiding scheme No. 61.

For meaning of terms consult synopsis No. 336, 338—342.

General characters (shape, dimensions, colour, odour, taste, surface, statistical data) should be mentioned in their proper places, some of which have been indicated below; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. composition of pollen.
    - 2a. dusty powder.
    - 2b. more coherent powder.
    - 2c. diplo-pollen.
    - 2d. tetrade pollen.
    - 2e. sectile pollen.
    - 2f. pollinium.
        - 3a. pollinium proper.
        - 3b. caudicle.
        - 3c. adhesive disc (rostellum).
- 1b. external characters of pollen-grains.
    - 2a. general shape, dimensions, colour and statistical data.
    - 2b. surface.
        - 3a. general characters.
        - 3b. grooves.
            - 4a. a single one.
            - 4b. more than one.
                - 5a. meridian, etc.

      - 3c. bands and crests of more considerable dimensions.
      - 3d. slighter projections: warts, spines etc.
      - 3e. places of exit.
        - 4a. number.
        - 4b. arrangement.
          - 5a. one place of exit.
            - 6a. basisyphonic pollen-grains.
            - 6b. acrosyphonic pollen-grains.
          - 5b. more than one place of exit.
            - 6a. equatorial arrangement.
            - 6b. scattered over the surface.
- 1c. organography of contents.
  - 2a. prothallium of numerous cells.
  - 2b. a single prothallium cell and a single antheridium cell, the latter ultimately producing a tube cell and two spermatozoids.
  - 2c. two prothallium cells and a single large cell, the latter ultimately producing a tube cell and two male cells or cell-nuclei.
  - 2d. a large tube cell and an antheridium mother cell, ultimately producing two male or generative cells; prothallium cells wanting.
- 1d. germination.
  - 2a. pollen-tube branched and performing the function of a haustorium.
  - 2b. pollen-tube unbranched and forming a passage for the male cells towards the egg-cell.

No. 50. Guiding scheme for the description of an ovule, ready for fertilisation.

For meaning of terms consult synopsis No. 356—359, No. 367, 368.

General characters (shape, dimensions, colour, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. reciprocal arrangement of its parts.
  - 2a. orthotropous, atropous or straight.
  - 2b. anatropous.
  - 2c. semianatropous or amphitropous.
  - 2d. campylotropous.
  - 2e. camptotropous.
- 1b. disposition within the ovary.
  - 2a. erect.
  - 2b. pendulous.
  - 2c. horizontal.
  - 2d. oblique.
    - 3a. ascendant.
    - 3b. descendant.
  - 2e. disposition of raphe.
    - 3a. ventral.
    - 3b. dorsal.
- 1c. description of its parts.
  - 2a. funicle.

- 3a. aril.
- 3b. strophiole.
- 2b. raphe.
- 2c. nucellus or kernel.
  - 3a. chalaza.
  - 3b. embryo-sac.
    - 4a. female pluricellular prothallium (see guiding scheme No 25) producing archegonia (see guiding scheme No. 19, gametangia).
    - 4b. central cell with secondary cell nucleus; egg-apparatus with egg-cell and synergids; antipodal cells.
      - 5a. acrogamic embryo-sac.
      - 5b. basigamic embryo-sac.
  - 3b. pollen-chamber.
- 2d. integuments, with micropyle or foramen; in some cases obturator.
  - 3a. monochlamydeous ovule.
  - 3b. dichlamydeous ovule.
    - 4a. outer or external integument or primine, with exostome.
      - 5a. caruncle.
      - 5b. arillode.
    - 4b. inner or internal integument or secundine with endostome.

No. 51. Guiding scheme for the determination of special kinds of fruits. In making descriptions the general guiding scheme No. 52 should always be consulted.

For meaning of terms consult synopsis No. 394—399.

- 1a. simple fruits.
  - 2a. dry fruits.
    - 3a. indehiscent.
      - 4a. coherence between wall of pericarp and seed-coat.
        - 5a. caryopsis or grain.
      - 4b. no coherence between wall of pericarp and seed-coat.
        - 5a. akene.
        - 5b. nut.
          - 6a. samara or key.
    - 3b. dehiscent.
      - 4a. schizocarp.
        - 5a. mericarp remaining closed.
          - 6a. diakenium.
            - 7a. double samara or double winged fruit.
          - 6b. triakenium.
          - 6c. tetrakenium.
          - 6d. polyakenium.
        - 5b. mericarps opening.
          - 6a. dicoccous fruit.
          - 6b. tricoccous fruit.
          - 6c. pentacoccous fruit.
      - 4b. capsule.

- 5a. arising from a simple pistil.
  - 6a. follicle.
  - 6b. legume.
- 5b. arising from a compound pistil.
  - 6a. silique.
    - 7a. silicle.
  - 6b. capsule proper.
- 2b. fleshy fruits.
  - 3a. berry.
    - 4a. dry berry.
  - 3b. drupe.
    - 4a. monopyrenous.
    - 4b. containing more than one stone.
      - 5a. dipyrenous.
      - 5b. tripyrenous.
      - 5c. tetrapyrenous etc.
  - 3c. apple or pome.
  - 3d. pepo or gourd-fruit.
  - 3e. hesperidium.
- 1b. accessory or anthocarpous fruits.
  - 2a. fig fruit or syconus.
  - 2b. strawberry.
  - 2c. cynarrhodion.
    - 3a. partial fruits or fruitlets.
  - 2d. mulberry.
  - 2e. pine-apple.
  - 2f. cone.
  - 2g. galbulus.

No. 52. General guiding scheme for the description of a ripe fruit.

For meaning of terms consult synopsis No. 381—393.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. the fruit proper.
  - 2a. pericarp.
    - 3a. wall, or in mericarps the parts corresponding to the wall of the ovary.
      - 4a. in fruits arising from superior and inferior ovaries.
        - 5a. exocarp or epicarp.
        - 5b. mesocarp.
          - 6a. sarcocarp.
        - 5c. endocarp.
      - 4b. in fruits arising from inferior ovaries only.
        - 5a. ribs.
          - 6a. primary ribs.
            - 7a. carinal.
            - 7b. commissural.

7c. marginal.
7d. dorsal.
6b. secondary ribs.
5b. valleculae.
6a. vittae as slightly protruding ridges.
3b. dissepiments; in mericarps the parts corresponding to the dissepiments of the ovary.
4a. commissure.
5a. vittae as slightly protruding ridges on the inside of the mericarps.
4b. columella or carpophore.
3c. placentae.
4a. parietal.
4b. axile.
4c. central.
4d. replum.
3d. dehiscence.
4a. schizocarps.
5a. columella or carpophore bearing the mericarps.
6a. from the dissepiments (See 3b.)
6b. from the style (See guiding scheme No. 47).
4b. capsule.
5a. splitting of ventral suture.
5b. valves.
6a. loculicidal.
6b. septicidal.
6c. septifragal.
6d. with a replum.
5c. teeth.
5d. clefts.
5e. pores or poricidal.
5f. circumscissile with operculum (pyxis).
2b. Seeds. See guiding scheme No. 53.
1b. other parts belonging to the fruit.
2a. peduncle of an inflorescence. See guiding scheme No. 46, inflorescence.
2b. bracts. See the same.
2c. cupule of *Cupuliferae.*
2d. floral receptacle. See guiding scheme No. 47, flower.
2e. perigon. See the same.
2f. calyx. See the same.
2g. style and stigmata. See the same.
3a. columella or carpophore and peripheral bands.

No. 53. Guiding scheme for the description of a ripe seed, and the development of a seedling from the seed.

For meaning of terms consult synopsis No. 386 and 400—423.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. exalbuminous seed.
  - 2a. funicle.
    - 3a. aril.
    - 3b. strophiole.
  - 2b. testa or seed-coat.
    - 3a. consistency, in some cases giving rise to:
      - 4a. sarcotesta.
      - 4b. sclerotesta.
      - 4c. endotesta.
    - 3b. component parts.
      - 4a. outer integument or primine.
      - 4b. inner integument or secondine.
      - 4c. chalazal part.
      - 4d. nucellus.
      - 4e. endosperm.
    - 3c. surface.
      - 4a. hilus.
      - 4b. micropyle.
        - 5a. caruncle.
        - 5b. arillode.
      - 4c. chalaza.
      - 4d. raphe.
    - 3d. appendages of the testa.
      - 4a. coma.
      - 4b. wings (winged seed).
  - 2c. embryo.
    - 3a. number in each seed.
      - 4a. monembryony.
      - 4b. polyembryony.
        - 5a. in combination with sexual reproduction.
          - 6a. simple polyembryony.
          - 6b. cleavage polyembryony.
        - 5b. no combination with sexual reproduction.
          - 6a. adventitious embryos.
    - 3b. segmentation.
      - 4a. root part.
        - 5a. radicle.
        - 5b. buds of adventitious roots.
        - 5c. coleorhiza.
      - 4b. cormoid part.
        - 5a. spatial relations, to be examined for obtaining a preliminary survey; the results to be used in the description in their proper places. See guiding scheme No. 28.
          - 6a. relations between the symmetry of ovule and seed and the position of cotyledons.
          - 6b. phyllotaxy. See guiding scheme No. 31.
          - 6c. mode of junction of the higher placed phyllomes to the cotyledons. See guiding scheme No. 32.

          - 6d. aestivation. See guiding scheme No. 34.
          - 6e. vernation. See guiding scheme No. 35.
        - 5b segmentation.
          - 6a. hypocotyl and cotyledons.
            - 7a. number of cotyledons.
            - 7b. parts more or less akin to cotyledons.
              - 8a. scutellum.
              - 8b. epiblast.
              - 8c. coleoptilum.
            - 7c. description of cotyledons. See guiding scheme No. 57, phyllome.
          - 6b. plumule.
            - 7a. epicotyl.
            - 7b. first cauline leaves.
              - 8a. number.
              - 8b. description. See guiding scheme No. 57.
    - 3b. direction of embryo with respect to hilus of seed.
      - 4a. antitropous embryo.
      - 4b. homotropous embryo.
      - 4c. amphitropous embryo.
    - 3c. folding up of the embryo.
      - 4a. radicle and cotyledons parallel to each other.
        - 5a. pleurorhizous embryo.
        - 5b. notorrhizous embryo.
        - 5c. orthoploceous embryo.
      - 4b. radicle and cotyledons at right angles to each other.
        - 5a. spirolobous embryo.
        - 5b. diplecolobous embryo.
- 1b. albuminous seed.
  - 2a. funicle. See 1a, 2a.
  - 2b. testa. See 1a, 2b.
  - 2c. embryo. See 1a, 2c.
  - 2d. albumen, the origin of this albumen can be established only by investigating its development. See guiding scheme No. 50, ovule.
    - 3a. endosperm of the seed.
      - 4a. shape, and here in special cases:
        - 5a. orthospermous.
        - 5b. coelospermous.
        - 5c. campylospermous.
        - 5d. ruminated endosperm.
      - 4b. consistency, and here especially:
        - 5a. farinose.
        - 5b. carnose.
        - 5c. stony.
        - 5d. horny.
    - 3b. perisperm.
      - 4a. shape.
      - 4b. consistency. See 3a, 4b.
- 1c. development of seedling from seed.

- 2a. perforation of coleorhiza.
- 2b. functions of cotyledons.
  - 3a. storage of reserve materials.
  - 3b. suction of reserve materials.
  - 3c. growing out into first foliage leaves.
  - 3d. growing out into the only foliage leaf of the plant.
- 2c. place of cotyledons in seedling.
  - 3a. hypogaeous.
  - 3b. epigaeous.
- 2d. functions of endosperm.
  - 3a. storage of reserve materials.
  - 3b. suction of reserve materials.

C. Caulome.

No. 54. Guiding scheme for the determination of special forms of caulomes. In making descriptions the general guiding scheme No. 55 should always be consulted.

For meaning of terms consult synopsis No. 181—195.

- 1a. stem.
- 1b. trunk.
- 1c. culm or straw.
- 1d. calamus.
- 1e. creeping caulome.
- 1f. rhizome representing only a caulome.
- 1g. caudex or stock.
- 1h. hypocotyl and epicotyl.
- 1i. disc.
- 1k. tuber representing a caulome.
- 1l. spines representing caulomes.
- 1m. stem-tendrils.
- 1n. parts of caulomes belonging to fructifications.
  - 2a. pseudopodium.
  - 2b. scape.
  - 2c. peduncle of an inflorescence.
  - 2d. pedicels of an inflorescence.
  - 2e. receptacle of a flower.

No. 55. General guiding scheme for the description of a caulome.

For meaning of terms consult synopsis No. 174—180.

General characters (shape, dimensions, colour, taste, odour, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. life-time duration.
  - 2a. annual.
  - 2b. biennial.
  - 2c. perennial.
- 1b. with respect to surrounding medium.
  - 2a. aerial.
  - 2b. submerged.

  - 2c. subterranean.
- 1c. direction.
  - 2a. erect.
  - 2b. hanging down.
  - 2c. procumbent.
  - 2d. ascending.
  - 2e. drooping.
  - 2f. nodding.
  - 2g. climbing.
    - 3a. twining.
      - 4a. sinistrorse.
      - 4b. dextrorse.
- 1d. direction of branches.
  - 2a. fastigiate.
  - 2b. horizontal.
  - 2c. spreading.
  - 2d. pendulous.
  - 2e. inclining.
- 1e. transverse section.
  - 2a. terete.
  - 2b. triangular, quadrangular, etc.
- 1f. surface.
  - 2a. smooth.
  - 2b. costate; relation of ribs to leaf-insertions.
  - 2c. furrowed.
  - 2d. appendages.

D. Phyllome.

No. 56. Guiding scheme for the determination of special forms of phyllomes. In making descriptions the general guiding scheme No. 57 should always be consulted.

For meaning of terms consult synopsis No. 223—239.

- 1a. foliage leaves.
- 1b. scale leaves or leaf-scales.
  - 2a. bud-scales.
  - 2b. bulb-scales.
- 1c. twining phyllomes.
- 1d. amphigastria.
- 1e. leaf-spines.
- 1f. leaf-tendrils.
- 1g. pitchers.
- 1h. utricles.
- 1i. phyllomes, storing reserve material.
- 1k. organs of suction.
- 1l. phyllomes, being fructifications or belonging to them.
  - 2a. sporophylls.
    - 3a. sporophylls in general.
      - 4a. isosporophylls.
      - 4b. microsporophylls.

        4c. mega- or macrosporophylls.
        4d. fovea.
      3b. sporocarps.
        4a. number of loculi.
  2b. perichaetial phyllomes.
  2c. phyllomes of perianth.
  2d. nectaries representing phyllomes.

No. 57. General guiding scheme for the description of a phyllome.

For meaning of terms consult synopsis No. 196—222.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. life-time duration of the phyllome proper.
  - 2a. deciduous.
  - 2b. persistent.
  - 2c. permanent.
- 1b. appendages of the phyllome.
  - 2a. stipules.
    - 3a. exstipulate phyllome.
    - 3b. stipulate phyllome.
      - 4a. free stipules.
        - 5a. caducous.
        - 5b. deciduous.
        - 5c. persistent.
      - 4b. adnate stipules.
      - 4c. interpetiolar stipules.
      - 4d. axillary stipule.
      - 4e. antidromous stipule.
  - 2b. ochrea.
  - 2c. ligula.
  - 2d. stipellas.
- 1c. phyllome proper.
  - 2a. sheath.
  - 2b. petiole.
    - 3a. wanting.
      - 4a. sessile.
      - 4b. stem-clasping.
      - 4c. perfoliate.
      - 4d. connate.
      - 4e. decurrent.
    - 3b. petiolate.
      - 4a. ordinary petiole.
      - 4b. winged petiole.
      - 4c. phyllodium.
  - 2c. blade.
    - 3a. of simple phyllome.
      - 4a. outline.
        - 5a. greatest breadth in the middle part.

- 6a. orbicular.
  - 7a. peltate.
- 6b. oval or elliptical.
- 6c. oblong.
- 6d. lanceolate.
- 5b. greatest breadth towards the base.
  - 6a. ovate or egg-shaped.
  - 6b. triangular.
  - 6c. deltoid.
  - 6d. rhomboid.
- 5c. greatest breadth towards the apex.
  - 6a. obovate.
  - 6b. spatulate.
  - 6c. wedge-shaped.
  - 6d. obcordate.
- 5d. greatest breadth extends over almost the whole length
  - 6a. linear.
    - 7a. strap-shaped.
  - 6b. sword-shaped.
  - 6c. awl-shaped.
  - 6d. needle-shaped.

- 4b. apex.
  - 5a. acute or sharp-pointed.
  - 5b. blunt.
  - 5c. taper-pointed.
  - 5d. truncate or emarginate.
- 4c. base.
  - 5a. acute.
  - 5b. blunt.
  - 5c. truncate.
  - 5d. notched.
- 4d. veins.
  - 5a. divergent.
    - 6a. palminerved or palmately veined blade.
    - 6b. feather-veined blade.
  - 5b. united at apex of blade.
    - 6a. straight-veined blade.
    - 6b. curve-veined blade.
- 4e. intervenia.
- 4f. margin.
  - 5a. entire.
  - 5b. divided.
    - 6a. independent divisions.
      - 7a. sawed.
        - 8a. biserrate or duplicate-serrate.
      - 7b. repandus.
      - 7c. toothed.
      - 7d. crenated.
    - 6b. dependent divisions and veins.

7a. palmatilobate blade.
7b. palmatifid blade.
7c. palmatisect blade.
7d. pinnatilobate blade.
7e. pinnatifid blade.
7f. pinnatisect blade.
6c. divisions at the notched base; form of apex and basal laciniae.
7a. heart-shaped or cordate blade.
7b. kidney-shaped blade.
7c. arrow-headed blade.
7d. halbert-headed blade.
8a. eared blade.
3b. of compound phyllome.
4a. parts.
5a. rhachis. Of first, second, etc. order. See 1c, 2b.
5b. petiolules.
5c. leaflets. See 3a.
4b. forms.
5a. palmate.
6a. bifoliate.
6b. trifoliate.
6c. quadrifoliate.
6d. quinquefoliate.
6e. septemfoliate.
6f. novemfoliate.
6g. polyfoliate.
6h. biternate.
5b. pinnate (juga).
6a. unifoliate (articulation or joint).
6b. imparipinnate.
6c. paripinnate or equally pinnate.
6d. interruptedly pinnate.
6e. bipinnate.
6f. tripinnate.
5c. digitato-pinnate.

E. Root.

No. 58. Guiding scheme for the determination of special forms of roots. In making descriptions the general guiding scheme No. 60 should always be consulted.

For meaning of terms consult synopsis No. 434—446.

1a. aerial roots.
2a. column-roots or root-supports.
1b. pneumatophores.
1c. stilt-roots or prop-roots.
1d. root-tendrils.
1e. root-thorns or spiny roots.
1f. root-hapterae.

1g. root-haustoria or root-suckers.
1h. roots metamorphosed into organs of carbon assimilation.
1i. swimming-roots.
1j. root-tubers.
1k. root-tubercles of *Leguminosae.*
1l. buttress-roots or flange-roots.

No. 59. Guiding scheme for determining the origin of a root or root system.

For meaning of terms consult synopsis No. 426.

1a. primary root.
1b. adventitious or secondary roots.
  2a. growing from rhizomes representing only a caulome.
    3a. spatial relations between these roots and phyllotaxy of rhizome.
  2b. growing from cormoid rhizomes.
    3a. spatial relations between these roots and phyllotaxy of rhizome.
  2c. arising without spatial relation with phyllotaxy of cormus, but often with spatial relation to division of caulome into nodes and internodes.
    3a. a single root.
    3b. more than one up to many roots in the same area.
    3c. primordial or germ adventitious roots.
    3d. crown roots.
  2d. arising from dormant root-buds.
  2e. arising from single cells.

No. 60. General guiding scheme for the description of a root, comprising primary and adventitious roots, root-individuals, periodic and annual roots and root systems.

For meaning of terms consult synopsis No. 424—433.

General characters (shape, dimensions, colour, odour, taste, consistency, surface, statistical data) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. spatial relations.
  2a. succession of roots leading to the construction of a succession of roots formula.
    3a. uniaxial, biaxial, triaxial, etc. up to pluriaxial.
  2b. branching. See guiding scheme No. 6.
1b. parts of the root.
  2a. body of the root.
    3a. tap-root or conical root.
    3b. napiform or turnip-shaped root, with added internodes of caulome.
    3c. thread-shaped root.
      4a. fibrous root.
  2b. apex.

- 2c. root-hairs.
  - 3a. number on each square millimeter.
  - 3b. extent of root surface covered by them.
- 2d. calyptra.
  - 3a. root-pocket.

Group IV. Cytology.

No. 61. Guiding scheme for the cytological description of cellular elements: unicellular organisms provided with a cell-wall, parenchymatic elements, fibres, articulations of vessels, thyloses, naked cells, gametes, spores.

For meaning of terms consult synopsis: Cytology No. 456 to No. 551.

General characters (shape, dimensions, chemical composition, colour, consistency, surface, statistical data) should be mentioned in their proper places, some of which have been indicated below; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. cells provided with cell-walls.
  - 2a. the three dimensions of space.
  - 2b. shape.
  - 2c. wall.
    - 3a. thickness.
    - 3b. coarser structure.
      - 4a. middle lamella, containing the primary layers.
      - 4b. secondary thickening layers.
      - 4c. tertiary thickening layers.
    - 3c. finer structure.
      - 4a. stratification.
      - 4b. striation.
    - 3d. colour.
    - 3e. chemical character. Cuticle and cuticular layers; exosporium and endosporium; exine and intine of pollen-grains.
    - 3f. relief figures.
      - 4a. centripetal.
        - 5a. pits.
          - 6a. simple pits.
            - 7a. number and arrangement.
              - 8a. combined simple pits.
            - 7b. shape.
              - 8a. circular.
              - 8b. slit-like.
            - 7c. pit canal.
            - 7d. closing membrane.
          - 6b. bordered pits.
            - 7a. number and arrangement.
              - 8a. combined bordered pits.
            - 7b. shape.
              - 8a. circular.
              - 8b. slit-like.

            - 8c. scalariform.
          - 7c. border or halo.
            - 8a. primary border membrane.
            - 8b. secondary border membrane.
          - 7d. canal.
            - 8a. cavity or pit chamber.
            - 8b. not widened part of canal.
              - 9a. sharp edged aperture.
              - 9b. inner aperture.
              - 9c. outer aperture.
          - 7e. closing membrane.
            - 8a. sieve-structure.
            - 8b. torus.
            - 8c. margo.
            - 8d. pectic annulus.
        - 6c. unilateral or semi-bordered pits. See 6a and 6b.
      - 5b. annular bands.
      - 5c. spiral bands.
      - 5d. reticulate thickenings.
      - 5a. cystoliths, rod-shaped thickenings and transverse bars.
      - 5f. collenchymatous thickenings.
    - 4b. centrifugal.
      - 5a. cuticular striation.
      - 5b. warts and knobs (file hairs).
      - 5c. protuberances of spores and pollen-grains.
  - 3a. crystals within the cell-wall.
    - 4a. simple crystals.
    - 4b. raphides.
    - 4c. cluster crystals.
    - 4d. crystal sand.
    - 4e. sphaerites.
  - 3h. siliceous bodies in the cell-wall.
  - 3i. perforations of the cell-wall.
    - 4a. ordinary perforations.
      - 5a. number, arrangement, shape and dimensions.
    - 4b. perforations for connecting threads of protoplasm.
      - 5a. number, arrangement, shape and dimensions.
  - 3k. schizogenous intercellular spaces.
    - 4a. dimensions and shape.
    - 4b. connecting frames ("cadres d'union" of Mangin).
    - 4c. rodlets ("bâtonnets" of Mangin).
- 2d. contents.
  - 3a. protoplast.
    - 4a. parietal cytoplasm and strings of protoplasm.
      - 5a. thickness.
      - 5b. microsomes.
      - 5c. chondriosomes or mitochondria.
      - 5d. internal streaming movements.
        - 6a. rapid.

            - 7a. rotation.
            - 7b. circulation.
                - 8a. parietal.
                - 8b. central.
            - 7c. streaming to and fro.
        - 6b. slow movements of orientation.
            - 7a. epistrophe.
            - 7b. apostrophe.
            - 7c. systrophe.
    - 5e. connecting threads (plasmodesms).
- 4b. nucleus and centrosomes.
    - 5a. nucleus.
        - 6a. number and arrangement.
        - 6b. shape and dimensions.
        - 6c. nucleoli; number, shape and dimensions.
        - 6d. nuclear membrane.
        - 6e. nuclear network (chromosomes).
        - 6f. nuclear sap.
        - 6g. protein crystals.
    - 5b. centrosomes.
        - 6a. number and arrangement.
- 4c. plastids.
    - 5a. number and arrangement.
    - 5b. shape and dimensions.
    - 5c. colour.
        - 6a. chloroplasts.
            - 7a. chloroplasts proper.
            - 7b. spurious chloroplasts.
        - 6b. leuco- or amyloplasts.
        - 6c. chromoplasts.
    - 5d. starch-grains.
        - 6a. simple.
            - 7a. shape, dimensions and position within the plastid.
            - 7b. stratification.
            - 7c. hilum.
                - 8a. central.
                - 8b. excentric.
        - 6b. compound.
            - 7a. number of component grains. For the rest see 6a.
        - 6c. half-compound. See 6b.
    - 5e. albumen crystals.
    - 5f. amylum-bodies.
        - 6a. pyrenoids.
        - 6b. starch-grains.
- 4d. vacuoles.
    - 5a. ordinary vacuoles.
        - 6a. sap cavities.
            - 7a. number and arrangement.
            - 7b. shape and dimensions.

- 7c. tonoplast.
- 7d. contents.
  - 8a. chemical characters of fluid contents.
  - 8b. aleurone grains.
    - 9a. albumen crystals.
    - 9b. globoids.
    - 9c. crystals of calcium oxalate.
  - 8c. crystals.
    - 9a. simple crystals.
    - 9b. raphides.
    - 9c. cluster crystals.
    - 9d. crystal sand.
  - 8d. siliceous bodies.

6b. adventitious vacuoles. See 6a.
5b. contractile vacuoles.
6a. rhythm of contraction.
3b. contents of dead cells.
3c. thyloses. To be described like cells.
1b. naked cells.
2a. pseudopodia.
2b. cilia, flagella and undulating membranes.
3a. blepharoplast.
2c. eye-spot.
3a. pigment layer.
3b. starch-grains.
3c. lens.
See moreover 1a.

No. 62. Guiding scheme for the determination of the mode of cell reproduction and the description of cells in a state of reproduction.

For meaning of terms consult synopsis No. 509—513.

- 1a. modes of reproduction.
  - 2a. cell division.
    - 3a. cell division in connection with nuclear division.
      - 4a. ordinary cell division.
        - 5a. successive cell division.
        - 5b. simultaneous cell division.
      - 4b. free cell formation.
    - 3b. cell division independent of nuclear division (free nuclear division).
  - 2b. cell budding.
- 1b. cells in a state of reproduction.

For general characters and conditions (shape, dimensions, chemical composition, colour, consistency, surface, statistical data) see guiding scheme No. 7.

For the several modes of cell reproduction mentioned above the condition ought to be described of:

- 2a. the cytoplasm. See guiding scheme No. 61.
- 2b. the nucleus or nuclei. See guiding scheme No. 63.

- 2c. plastids. See guiding scheme No. 61.
- 2d. vacuoles. See guiding scheme No. 61.
- 2e. the original cell-wall.
- 2f. protoplasmic fibres, preceding the partition wall.
  - 3a. connecting fibres.
  - 3b. fibres radiating into the cytoplasm.
- 2g. cell plate.
- 2h. newly formed partition wall.
  - 3a. simultaneously formed.
  - 3b. successively formed.

No. 63. Guiding scheme for the determination of mode and phases of nuclear division and the description of nuclei in a state of division.

For meaning of terms consult synopsis No. 470—483, 485, 486.

- 1a. modes and phases of nuclear division.
  - 2a. amitosis or direct nuclear division.
  - 2b. karyokinesis, mitosis or indirect nuclear division.
    - 3a. typical karyokinesis.
      - 4a. ordinary karyokinesis.
        - 5a. prophases.
          - 6a. mother nucleus, ready for division.
          - 6b. spirem or skein-stage.
          - 6c. aster or monaster stage.
        - 5b. metaphases.
          - 6a. metakinesis, equatorial plate, heteropolia.
        - 5c. anaphases.
          - 6a. diaster stage.
          - 6b. dispirem.
          - 6c. daughter nuclei.
      - 4b. conjugated karyokinesis. See 4a.
    - 3b. allotypic karyokinesis or reduction division.
      - 4a. heterotype reduction division with gemini, synapsis and diakinesis. See moreover 3a.
      - 4b. homotype reduction division with nuclei of tetrad cells. See moreover 3a.
- 1b. nuclei in a state of division.

For general characters and conditions (shape, dimensions, chemical composition, etc.) see guiding scheme No. 7.

For each of the stages of karyokinesis mentioned above the condition ought to be described of:

- 2a. nuclear membrane.
- 2b. nuclear network or chromosomes. Polar field, longitudinal fission, number of chromosomes and of genoms.
  - 3a. haploid nucleus (a single genom).
  - 3b. diploid nucleus (two genoms).
  - 3c. triploid, tetraploid etc. nucleus (three, four, etc. genoms).
- 1c. nucleoli.
- 1d. nuclear sap.
- 1e. nuclear spindle.

    - 2a. spindle poles.
    - 2b. supporting fibres.
    - 2c. traction fibres.
- 1f. astrospheres or attraction spheres.
- 1g. centrosomes and centrioles.

No. 64. Guiding scheme for describing the development of a tetrad after reduction division.

For meaning of terms consult synopsis No. 484.

- 1a. quadripartition type or simultaneous type of cell division.
    - 2a. tetrahedral arrangement of granddaughter cells; shape of same.
    - 2b. arrangement of granddaughter cells in a single flat plane; shape of these cells.
    - 2c. formation of partition walls.
        - 3a. simultaneous.
        - 3b. successive or furrowing.
- 1b. bipartition type or successive type of cell division.
    - 2a. shape of granddaughter cells; reciprocal arrangement of the two pairs of granddaughter cells.
        - 3a. parallel.
        - 3b. cross-wise.
        - 3c. intermediate stages.
    - 2b. formation of partition walls.
        - 3a. simultaneous.
        - 3b. successive or furrowing.

Group V. General Histology.

No. 65. Guiding scheme for the histological determination of single cells.

For meaning of terms consult synopsis No. 544—567.

- 1a. meristematic cells. See 1b.
- 1b. permanent cells.
    - 2a. shape.
        - 3a. parenchymatic elements.
            - 4a. parenchyma cells.
            - 4b. hyphae.
                - 5a. pseudoparenchymatic elements.
        - 3b. fibres or prosenchymatic elements.
    - 2b. characters of cell-wall.
        - 3a. thickness.
            - 4a. thin-walled elements.
                - 5a. thin-walled or common parenchyma cells.
                - 5b. thin-walled fibres.
            - 4b. collenchymatous elements.
                - 5a. collenchymatous parenchyma cells.
                - 5b. collenchyma fibres.
            - 4c. sclerenchymatous elements.
                - 5a. sclereids, sclerenchyma cells or stone cells.

        - 5b. collenchyma fibres.
    - 3b. cell-wall substances.
        - 4a. cuticularised cells.
        - 4b. periderm cells.
        - 4c. cells of protective sheath (Casparian strips).
        - 4d. mucilage cells.
        - 4e. stegmata or covering plates.
    - 3c. relief figures.
        - 4a. pitted cells and fibres.
            - 5a. with simple pits.
            - 5b. with bordered pits.
                - 6a. transfusion tissue cells.
        - 4b. annular and spiral cells and fibres.
        - 4c. reticulate cells and fibres.
    - 3d. cells with infolded walls.
    - 3e. absciss cells.
- 2c. characters of cell-contents.
    - 3a. chlorenchyma cells.
    - 3b. water-reservoir or water-storage cells.
        - 4a. living.
        - 4b. dead.
    - 3c. aleurone cells.
        - 4a. gluten cells.
    - 3d. starch cells.
    - 3e. sugar cells.
    - 3f. oil cells (fatty or ethereal).
    - 3g. inulin cells.
    - 3h. tannin cells.
    - 3i. anthocyanin cells.
    - 3j. enzyme cells.
    - 3k. alkaloid cells.
    - 3l. mucilage cells.
    - 3m. latex cells.
- 2d. glandular cells.

1c. special terms used in the description of compound tissues see schemes No. 71—79.

1d. special terms used in the description of tissue systems see schemes No. 80—88.

No. 66. Guiding scheme for the determination and description of vessels.

For meaning of terms consult synopsis No. 568—583.

General characters (shape, dimensions, chemical composition, colour, consistency, surface, statistical data) should be mentioned in their proper places, some of which have been indicated beneath; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. xylem vessels.
    - 2a. with respect to the relief figures on the lateral walls:
        - 3a. annular vessels.

        - 3b. spiral vessels.
        - 3c. reticulate vessels.
        - 3d. pitted vessels.
        - 3e. scalariform vessels.
    - 2b. dimensions.
        - 3a. thickness.
        - 3b. length of articulations and total length of vessels.
    - 2c. shape.
    - 2d. partition walls.
        - 3a. direction.
            - 4a. horizontal.
            - 4b. oblique.
        - 3b. perforations.
            - 4a. shape.
                - 5a. circular or oval.
                - 5b. scalariform.
            - 4b. number, place, arrangement and dimensions. Dimensions of the remaining parts of the transverse walls.
            - 4c. margin.
                - 5a. smooth.
                - 5b. bordered pit-like.
    - 2e. lateral wall. See guiding scheme No. 61: 1a, 2c.
    - 2f. contents. See guiding scheme No. 61: 1a, 2d.
- 1b. sieve tubes.
    - 2a. dimensions, also length of articulations.
    - 2b. shape.
    - 2c. partition walls.
        - 3a. direction.
            - 4a. horizontal.
            - 4b. oblique.
        - 3b. sieve plates.
            - 4a. number, place, arrangement (scalariform etc.) and dimensions.
            - 4b. shape.
    - 2d. lateral walls.
        - 3a. sieve plates. See for the rest of lateral walls guiding scheme No. 61: 1a, 2c.
    - 2e. contents.
        - 3a. callus plates. See for the rest guiding scheme No. 61: 1a, 2d, 3a.
- 1c. latex vessels.
    - 2a. dimensions and shape.
    - 2b. transverse walls and perforations.
    - 2c. lateral walls. See guiding scheme No.61: 1a, 2c.
    - 2d. contents. See guiding scheme No. 61: 1a, 2d, 3a.
- 1d. tannin vessels.

No. 67. Guiding scheme for determining the mode of growth and formation of tissues.

For meaning of terms consult synopsis No. 615—628.
1a. origin of tissues.
  2a. repeated cell divisions.
    3a. meristems. See guiding schemes No. 69 and No. 70.
      4a. distribution of cell divisions. See guiding scheme No. 70.
    3b. division of adult cells.
      4a. distribution of cell divisions. See guiding scheme No. 70.
  2b. association of previously isolated cells.
1b. growth and formation of tissue.
  2a. both combined.
  2b. formation of tissue wanting.
  2c. growth wanting.
1c. succession of order in growth and in tissues.
  2a. primary growth and tissues.
    3a. from full meristems.
    3b. from cambia.
    3c. radial arrangement of cells.
    3d. differentiation of cells taken place either before or after the end of longitudinal growth.
  2b. secondary growth and tissues.
    3a. from cambia.
    3b. in dilatation tissues.
    3c. radial arrangement of cells.
  2c. tertiary, quaternary, etc. growth, and tissues.
1d. dilatation growth and tissues.
  2a. dilatation growth without dilatation tissue.
  2b. dilatation growth with dilatation tissue.

No. 68. Guiding scheme for the histological determination of a tissue in general. This scheme contains the terms used in the description of simple tissues, but not those for compound tissues and tissue systems. For compound tissues the student is referred to the schemes No. 71—79; for the description of tissue systems the schemes belonging to special histology No. 80—88 should be consulted.

For meaning of terms consult synopsis No. 553—567 and No. 615, 616, 617, 619 and 629—637.
1a. characters of cellular elements in tissues.
  2a. meristem or meristematic tissue. See 2b.
  2b. permanent, fixed or mature tissue.
    3a. shape.
      4a. parenchymatic tissues.
        5a. parenchyma.
        5b. hyphal tissue or plectenchyma.
          6a. pseudoparenchyma.
      4b. prosenchyma.
    3b. characters of cell-wall.
      4a. thickness.
        5a. thin-walled elements.
          6a. thin-walled or common parenchyma.

- 6b. thin-walled prosenchyma.
- 5b. collenchyma.
  - 6a. collenchymatic parenchyma.
  - 6b. collenchymatic prosenchyma.
- 5c. sclerenchyma.
  - 6a. sclerenchymatic parenchyma.
  - 6b. sclerenchymatic prosenchyma.
- 4b. cell-wall substances.
  - 5a. periderm.
- 4c. relief-figures.
  - 5a. transfusion tissue.
- 4d. absciss tissue.
- 3c. characters of cell contents.
  - 4a. chlorenchyma.
  - 4b. water tissue or water-storage tissue.
    - 5a. living.
    - 5b. dead.
  - 4c. gluten tissue.

See moreover scheme No. 65.

- 1b. intercellular spaces.
  - 2a. wanting.
  - 2b. schizogenous. See guiding scheme No. 61.
    - 3a. spongy tissue.
      - 4a. spongy chlorenchyma.
    - 3b. aerenchyma.
  - 2c. lysigenous.
- 1c. extension of tissue.
  - 2a. idioblasts.
  - 2b. cell-clusters.
  - 2c. cell-rows.
  - 2d. bundles.
  - 2e. layers.
    - 3a. sheaths.
      - 4a. protective sheath.
      - 4b. starch-sheath.
      - 4c. protective sheath and starch-sheath combined.
      - 4d. sclerenchyma sheath.
      - 4e. crystal-sheath.
      - 4f. sheath of stegmata or covering-plates.
      - 4g. periderm-sheath.
      - 4h. cambium-sheath.
      - 4i. root-sheath or velamen.
    - 3b. hypoderma.
    - 3c. epithelium.
    - 3d. palisade tissue.
    - 3e. absciss layer.

No. 69. Guiding scheme for the histological determination of meristems in their relation to the adult tissues.

For meaning of terms consult synopsis No. 618—623.

1a. only meristem present (primitive meristem).
1b. meristem and adult tissue both present.
  2a. primary meristem.
    3a. full meristem.
      4a. apical (vegetative cone).
      4b. basal.
    3b. cambium.
      4a. one-sided or monopleuric.
      4b. two-sided or dipleuric.
  2b. secondary, tertiary etc, meristem.
  Subdivision like 2a.

No. 70. Guiding scheme for the histological description of meristems themselves.

For meaning of terms consult synopsis No. 624—626.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. diffuse growth.
  2a. polygenous growth in cambia.
1b. transit celled growth of cambia.
  2a. mother-cells, their number, and number of divisions.
1c. initial celled growth, including monogenous growth of cambia.
  2a. initial cells.
    3a. a limited number of initial cells (vegetative points).
      4a. apical cell.
      4b. a small group of initial cells.
    3b. a large number of initial cells (cambia and intercalary meristems).
      4a. storied, tier-like or stratified arrangement.
      4b. non-stratified arrangement.
  2b. segments of the apical cell and ordinary meristem cells.
  2c. procambium.
  2d. adult elements.
    3a. trichomes.
    3b. spiral vessels.
    3c. crystal cells.
    3d. oil cells.
    3e. oblito-schizogenous glands.

No. 71. Guiding scheme for the histological determination and description of stomatic apparatus.

For meaning of terms consult synopsis No. 639—643.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. ordinary stomata.
  2a. cryptoporous.
    3a. vestibule.

- 3b. guard cells.
- 3c. porus.
  - 4a. front chamber.
  - 4b. slit.
  - 4c. back chamber.
- 3d. respiratory cavity or air cavity.
- 3e. subsidiary cells.

2b. phaneroporous. See 2a, with the exception of the vestibule.

1b. water-pores.

See 1a, 2b.

No. 72. Guiding scheme for the histological determination and description of emissaries (hydathodes).

For meaning of terms consult synopsis No. 639, 647, 648.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. epidermal emissaries.
  - 2a. ordinary emissaries.
    - 3a. unicellular.
    - 3b. pluricellular.
  - 2b. trichome emissaries.
- 1b. emissaries provided with the ends of xylem bundles.
  - 2a. water-pores wanting.
    - 3a. excreting cells.
    - 3b. ends of xylem bundles.
  - 2b. water-pores present.
    - 3a. water-pores.
      - 4a. number and arrangement.
      - 4b. shape. See guiding scheme No. 71.
    - 3b. epithema.
    - 3c. ends of xylem bundles.
  - 2c. apical openings.
    - 3a. cuticle.
    - 3b. cavity.
    - 3c. ends of xylem bundles.

No. 73. Guiding scheme for the histological determination and description of internal glands.

For meaning of terms consult synopsis No. 639, 644—646.

General characters (shape, dimensions etc.) should be mentioned in their proper places; some of them indicated below; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. schizogenous glands, including vittae.
  - 2a. dimensions and shape.
  - 2b. epithelium.
  - 2c. sheath.
    - 3a. parenchyma sheath.
    - 3b. sclerenchyma sheath.

        - 4a. sclerenchymatic elements.
        - 4b. passage cells.
    - 2d. cavity and contents.
- 1b. oblito-schizogenous and schizo-lysigenous glands.
    - 2a. dimensions and shape.
    - 2b. epithelium.
    - 2c. sheath.
        - 3a. parenchyma sheath.
        - 3b. sclerenchyma sheath.
            - 4a. sclerenchymatic elements.
            - 4b. passage cells.
    - 2d. cavity and contents.
    - 2e. cover and evacuation slit.

No. 74. Guiding scheme for the histological determination and description of a primary vascular bundle.

For meaning of terms consult synopsis No. 638, 639 and No. 649—659.

General characters (shape, dimensions etc.), should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. simple vascular bundle.
    - 2a. closed.
        - 3a. collateral.
            - 4a. phloem.
                - 5a exarch or endarch.
                    - 6a. protophloem.
                        - 7a. primitive or primordial cribral elements.
                            - 8a. sieve tubes. See guiding scheme No. 66.
                            - 8b. companion cells.
                        - 7b. cambiform cells.
                        - 7c. flattened elements.
                    - 6b. metaphloem.
                        - 7a. cribral elements.
                            - 8a. sieve tubes. See guiding scheme No. 66.
                            - 8b. companion cells.
                        - 7b. cambiform cells.
            - 4b. connecting parenchyma.
            - 4c. xylem.
                - 5a. exarch, mesarch or endarch.
                    - 6a. protoxylem.
                        - 7a. primitive or primordial xylem elements.
                            - 8a. xylem vessels. See guiding scheme No. 66.
                            - 8b. tracheids.
                        - 7b. xylem parenchyma.
                        - 7c. intercellular space.
                        - 7d. flattened or destroyed elements.
                    - 6b. metaxylem.
                        - 7a. tracheal elements.

- 8a. xylem vessels. See guiding scheme No. 66.
- 8b. tracheids.
- 7b. xylem parenchyma.
- 7c. libriform.
- 3b. bicollateral.
  - 4a. outer phloem. See 3a, 4a.
  - 4b. connecting parenchyma.
  - 4c. xylem. See 3a, 4c.
  - 4d. connecting parenchyma.
  - 4e. inner phloem. See 3a, 4a.
- 3c. concentric.
  - 4a. amphivasal. See 3a.
  - 4b. amphicribral. See 3a.
- 2b. open.
  - 3a. collateral. See 2a, 3a, but cambium replacing the connecting parenchyma.
  - 3b. bicollateral. See 2a, 3b, but cambium at least partly replacing the connecting parenchyma.
- 1b. compound vascular bundle.
  - 2a. simple bundles composing the compound vascular bundle.
    - 3a. number and arrangement within the compound bundle. See moreover 1a.
  - 2b. medullary commissures within the compound bundle.
    - 3a. thin-walled parenchyma.
    - 3b. idioblasts.

No. 75. Guiding scheme for the histological description of a fibro-vasal bundle.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. sclerenchyma sheath.
  - 2a. elements of the above.
- 1b. vascular bundle. See guiding scheme No. 74.

No. 76. Guiding scheme for the histological determination and description of secondary cork tissue.

For meaning of terms consult synopsis No 662—668.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. secondary cork tissue proper.
  - 2a. initial celled or monogenous cork.
    - 3a. phellem.
      - 4a. growth rings.
      - 4b. part taken by the several elements in the construction of the phellem.
        - 5a. periderm.
        - 5b. phelloid.

5c. sclerenchyma.
5d. aerenchyma.
3b. phellogen.
3c. phelloderm.
4a. ordinary phelloderm cells.
4b. idioblasts.
2b. transit celled polygenous cork.
3a. mother-cells of transit celled polygenous cork. Number, and number of divisions.
4a. periderm.
1b. lenticels.
2a. number and arrangement.
2b. phellem.
3a. complementary tissue.
3b. closing membranes or intermediate bands.
3c. aerenchyma.
2c. phellogen.
2d. phelloderm.
3a. ordinary phelloderm cells.
3b. idioblasts.

No. 77. Guiding scheme for the histological description of secondary phloem.

For meaning of terms consult synopsis No. 688—699 and moreover 584—586 and 605—614.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. rhytidoma.
2a. scaly rhytidoma.
3a. dimensions and shape of scales.
3b. ordinary secondary phloem. See 1b.
3c. secondary cork layers and lenticels. See guiding scheme No. 76.
2b. annular rhytidoma. See 2a.
1b. secondary phloem proper.
2a. growth rings.
2b. part taken by the several elements in the construction of the phloem.
3a. phloem without storied arrangement.
4a. elements of the cribral class.
5a. sieve tubes.
5b. companion cells.
5c. keratenchyma.
4b. elements of the class of bast fibres.
5a. non septate bast fibres.
6a. sclerenchymatic.
6b. thin-walled.
5b. septate bast fibres. See 5a.

4c. elements of the parenchymatic class.
  5a. bast parenchyma.
    6a. arrangement.
      7a. metacribral.
    6b. part taken by the several elements in the construction of the bast parenchyma.
      7a. septate bast parenchyma fibres.
        8a. regular bast parenchyma.
          9a. thin-walled parenchyma.
          9b. conjugated parenchyma.
          9c. sclerenchyma.
          9d. idioblasts.
          9e. internal glands. See guiding scheme No. 73.
        8b. irregular bast parenchyma. See 8a.
      7b. substitute fibres. See 9a—e under 7a.
  5a. medullary rays.
    6a. simple medullary rays.
      7a. procumbent cells.
        8a. thin-walled procumbent cells.
        8b. sclerenchyma.
        8c. idioblasts.
      7b. upright or erect cells. See 7a.
      7c. internal glands. See guiding scheme No. 73.
    6b. compound medullary rays. See 6a.
4d. latex vessels. See guiding scheme No. 66.
3b. phloem with storied arrangement. See 3a.
2c. dilatation tissue.
  3a. in bast parenchyma and medullary rays.
  3b. in bast parenchyma only.
  3c. in medullary rays only.
  3d. in parenchyma only, leading to the formation of wedges with their bases turned outwards.

No. 78. Guiding scheme for the histological description of secondary xylem.

For meaning of terms consult synopsis No. 671—687 and moreover 584—586 and 587—604.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. sap-wood (alburnum).
  2a. growth rings (annual rings, year rings).
    3a. early wood (spring wood).
    3b. middle layer.
    3c. late wood (autumn wood).
  2b. part taken by the several elements in the construction of the xylem.
    3a. xylem without storied arrangement.
      4a. elements of the tracheal class.

5a. vessels.
6a. number and arrangement. See moreover guiding scheme No. 66.
5b. tracheids.
6a. vascular or vessel tracheids.
7a. ordinary.
7b. conjugated.
6b. fibre tracheids.
4b. elements of the libriform class.
5a. non-septate libriform fibres.
5b. septate libriform fibres.
4c. elements of the parenchymatic class.
5a. wood parenchyma.
6a. arrangement.
7a. paratracheal (circumvasal).
7b. metatracheal (laminar).
7c. scattered among the other elements.
6b. part taken by the several elements in the construction of the wood parenchyma.
7a. septate wood parenchyma fibres.
8a. regular wood parenchyma.
9a. ordinary.
9b. conjugated.
9c. idioblasts.
9d. internal glands. See guiding scheme No. 73.
8b. irregular wood parenchyma. See 8a.
7b. substitute fibres. See 9a—d under 8a.
5b. medullary rays.
6a. simple medullary rays.
7a. procumbent cells.
8a. ordinary.
8b. idioblasts.
7b. upright or erect cells.
8a. ordinary.
8b. enveloping cells.
8c. conjugated.
8d. idioblasts.
7c. tile-shaped cells.
7d. tracheidal medullary ray cells or ray-tracheids.
7e. internal glands. See guiding scheme No. 73.
6b. compound medullary rays. See 6a.
4d. phloem bundles. See guiding scheme No. 77.
3b. xylem with storied arrangement. See 3a.
1b. heart wood (duramen) See 1a.
Appendix. Medullary spots or pith flecks.

No. 79. Guiding scheme for the histological description of secondary vascular bundle tissue.

For meaning of terms consult synopsis No. 700 and 701.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. secondary parenchyma formed towards the outside.
1b. cambium. See guiding schemes No. 69 and No. 70.
1c. secondary parenchyma formed towards the inside.
1d. secondary vascular bundles. See guiding scheme No. 74.

Group VI. Special Histology.

The following guiding schemes are sufficient for the description of all parts of the higher plants. Scale-leaves, tepals, sepals, petals, etc. ought to be described with the help of the guiding scheme for the phyllome.

No. 80. Guiding scheme for the histological description of more highly differentiated thallomes.

1a. epidermis.
  2a. epidermal cells.
  2b. stomata. See guiding scheme No. 71.
  2c. idioblasts.
  2d. appendages of the surface. See guiding scheme No. 88.
1b. ground tissue.
  2a. general description. See guiding scheme No. 68.
  2b. compound tissues. See the suitable guiding schemes.
  2c. appendages of internal surface. See guiding scheme No. 88.

No. 81. Guiding scheme for the histological description of the caulome.

For meaning of terms consult synopsis No. 702—709 and moreover 712—716.

General characters (shape, dimensions, etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and 8.

For the construction of a diagram showing the course of the vascular bundles through the caulome, consult synopsis No. 751 and Pl. II fig. 1.

1a. epidermis.
  2a. primary epidermal tissue.
    3a. epidermis proper.
      4a. epidermal cells.
      4b. stomata. See guiding scheme No. 71.
      4c. idioblasts.
      4d. appendages of the surface. See guiding scheme No. 88.
    3b. water tissue.
  2b. secondary tissue.
    3a. cambial tissue; secondary cork tissue. See guiding scheme No. 76.
    3b. dilatation tissue or only dilatation growth.
1b. cortex.

- 2a. primary cortex layers proper.
  - 3a. collenchyma.
  - 3b. thin-walled parenchyma.
  - 3c. aerenchyma.
  - 3d. periderm.
  - 3e. sclerenchyma.
  - 3f. idioblasts.
  - 3g. latex vessels. See guiding scheme No. 66.
  - 3h. internal glands. See guiding scheme No. 73.
  - 3i. appendages of internal surfaces. See guiding scheme No. 88.
  - 3j. meristeles. See for the vascular or fibrovasal bundles of these guiding schemes No. 74 and 75.
- 2b. secondary tissues.
  - 3a. cambial tissue.
    - 4a. secondary cork tissue. See guiding scheme No. 76.
    - 4b. aerenchyma.
  - 3b. dilatation tissue.
- 2c. endodermis.
  - 3a. primary endodermis (L of its cells to compare with L of adjacent cells in cortex and pericambium).
    - 4a. protective sheath.
      - 5a. ordinary cells.
      - 5b. passage cells.
      - 5c. idioblasts.
    - 4b. starch-sheath. See 4a.
    - 4c. crystal-sheath. See 4a.
    - 4d. enzyme-sheath, etc. See 4a.
  - 3b. secondary endodermal tissue.
    - 4a. secondary cork tissue. See guiding scheme No. 76.
    - 4b. secondary vascular bundle tissue. See guiding scheme No. 79.

- 1c. stele.
  - 2a. pericycle.
    - 3a. primary pericycle.
      - 4a. thin-walled parenchyma.
      - 4b. sclerenchyma.
      - 4c. latex vessels. See guiding scheme No. 66.
      - 4d. idioblasts.
      - 4e. internal glands. See guiding scheme No. 73.
    - 3b. secondary pericycle.
      - 4a. secondary cork tissue. See guiding scheme No. 76.
      - 4b. secondary phloem and xylem. To be described with the interfascicular secondary phloem and xylem. See 2c, 3b, 4a, 5b, 6b and 6d.
      - 4c. adventitious roots. See guiding scheme No. 87.
      - 4d. secondary vascular bundle tissue. See guiding scheme No. 79.
  - 2b. vascular or fibrovasal bundles.
    - 3a. vascular bundles.

4a. secondary phloem and xylem either wanting or, if present, considered in its relation to the vascular bundles.
5a. simple vascular bundles.
6a. number and arrangement.
6b. secondary tissues wanting. See guiding scheme No 74.
6c. secondary tissues present.
7a. primary phloem. See guiding scheme No. 74.
7b. secondary phloem (fascicular phloem). See guiding scheme No. 77. (smaller medullary rays).
7c. cambium (fascicular cambium). See guiding schemes No. 69 and 70.
7d. secondary xylem (fascicular xylem). See guiding scheme No. 78 (smaller medullary rays).
7e. primary xylem. See guiding scheme No. 74.
5b. compound vascular bundles.
6a. number and arrangement.
6b. simple vascular bundles composing the compound bundles.
7a. number and arrangement within the compound bundles. See moreover 5a.
6c. medullary commissures within the compound bundles. See 2c.
4b. secondary phloem and xylem present, but not considered in its relation to the vascular bundles.
5a. primary phloem (see guiding scheme No. 74, primary vascular bundle) and corresponding primary part of the medullary commissures. See 2c, 3b, 4a, 5b, 6a.
5b. secondary phloem. See guiding scheme No. 77.
5c. cambium. See guiding schemes No. 69 and 70.
5d. secondary xylem. See guiding scheme No. 78.
5e. primary xylem (see guiding scheme No. 74, primary vascular bundle) and corresponding primary part of the medullary commissures. See 2c, 3b, 4a, 5b, 6e.
3b. fibrovasal bundle.
4a. sclerenchyma sheath.
5a. elements of the above.
4b. vascular bundles. See 3a.
2c. medullary commissures.
3a. monocotyledonous stem; to be described with the medulla.
3b. dicotyledonous stem.
4a. between the compound vascular bundles.
5a. secondary tissues wanting.
6a. thin walled parenchyma.
6b. idioblasts.
5b. secondary phloem and xylem present (large medullary rays).
6a. primary part corresponding with primary phloem of vascular bundles. See 5a.
6b. secondary part corresponding to secondary phloem of

vascular bundles (interfascicular secondary phloem). See guiding scheme No. 77, and if a part of the cambium is formed by the pericycle 2a, 3b, 4b.

6c. cambial part (interfascicular cambium). See guiding schemes No. 69 and 70.

6d. secondary part corresponding to secondary xylem of vascular bundles (interfascicular secondary xylem). See guiding scheme No. 78 and if a part of the cambium is formed by the pericycle 2a, 3b, 4b.

6e. primary part corresponding with primary xylem of vascular bundles. See 5a.

4b. between the simple vascular bundles. See 4a.

2d. medulla.
  3a. thin-walled parenchyma.
  3b. sclerenchyma.
  3c. idioblasts.
  3d. latex vessels. See guiding scheme No. 66.
  3e. internal glands. See guiding scheme No. 73.
  3f. phloem bundles. See guiding scheme No. 74.
  3g. vascular bundles, sometimes with secondary growth. See guiding schemes No. 74, 77 and 78.
  3h. secondary dilatation parenchyma.
  3i. lysigenous cavity.

No. 82. Guiding scheme for the histological description of the phyllome.

For meaning of terms consult synopsis No. 702—709 and moreover 717—720.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. blade.
  2a. intervenium.
    3a. epidermis.
      4a. epidermis proper.
        5a. epidermis of upper side.
          6a. epidermal cells.
          6b. stomata. See guiding scheme No. 71.
          6c. water pores. See guiding scheme No. 71.
          6d. idioblasts.
          6e. appendages of the surface. See guiding scheme No. 88.
          6f. periderm.
        5b. epidermis of under side. See 5a.
      4b. water tissue.
        5a. common parenchyma.
        5b. idioblasts.
    3b. mesophyll.
      4a. water tissue.
      4b. palisade chlorenchyma.

        - 4c. spongy chlorenchyma.
          - 5a. collecting or receiving cells.
        - 4d. appendages of inner surfaces.
        - 4e. sclerenchyma.
        - 4f. internal glands. See guiding scheme No. 73.
        - 4g. tissues containing spurious chloroplasts.
        - 4h. idioblasts.
- 2b. margin.
  - 3a. epidermis. See 2a, 3a.
  - 3b. collenchyma.
  - 3c. sclerenchyma.

See for the rest 2a, 3b.

2c. veins. If the stele is fully developed the guiding scheme for the stem is used for the main part. In all other cases the following scheme is used.

  - 3a. epidermis. See 1a, 2a, 3a.
  - 3b. mesophyll.
    - 4a. water tissue.
    - 4b. collenchyma.
    - 4c. colourless parenchyma.
    - 4d. palisade chlorenchyma.
    - 4e. spongy chlorenchyma.
    - 4f. sclerenchyma.
    - 4g. idioblasts.
    - 4h. internal glands. See guiding scheme No. 73.
    - 4i. appendages of internal surfaces. See guiding scheme No. 88.
    - 4j. endodermis.
      - 5a. protective sheath.
        - 6a. ordinary cells.
        - 6b. passage cells.
        - 6c. idioblasts.
      - 5b. starch-sheath. See 5a.
      - 5c. crystal-sheath. See 5a.
      - 5d. enzyme-sheath. See 5a.
  - 3c. meristeles.
    - 4a. pericycle.
      - 5a. thin-walled parenchyma.
      - 5b. sclerenchyma.
      - 5c. idioblasts.
    - 4b. vascular or fibrovasal bundles.
      - 5a. number and arrangement. See moreover guiding schemes No. 74 or 75.
    - 4c. medullary commissures between compound bundles.
      - 5a. thin-walled parenchyma.
      - 5b. idioblasts.
    - 4d. medulla.
      - 5a. thin-walled parenchyma.
      - 5b. idioblasts.

1b. stipules. See 1a.
1c. ochrea. See 1a.
1d. ligula. See 1a.
1e. sheath. See 1a.
1f. petiole. See 1a, 2c.

No. 83. Guiding scheme for the histological description of the stamen.

For meaning of terms consult synopsis No. 721.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. filament.
  2a. epidermis.
    3a. epidermal cells.
    3b. stomata. See guiding scheme No. 71.
    3c. idioblasts.
    3d. appendages of the surface. See guiding scheme No. 88.
  2b. mesophyll.
    3a. thin-walled parenchyma.
    3b. idioblasts.
    3c. internal glands. See guiding scheme No. 73.
    3d. endodermis.
  2c. meristele.
    3a. pericycle.
      4a. elements of the above.
    3b. vascular or fibrovasal bundle. See guiding scheme No. 74 or 75.
1b. anther.
  2a. connective.
    3a. epidermis. See 1a, 2a.
    3b. mesophyll. See 1a, 2b.
    3c. meristele. See 1a, 2c.
  2b. thecae.
    3a. epidermis. See 1a, 2a.
    3b. fibrous layer.
    3c. intermediate parietal layer.
    3d. tapetal layer.
    3e. partition wall between the loculi.
    3f. pollen.
      4a. exine.
      4b. intine.
      4c. places of exit.
      4d. contents.

No. 84. Guiding scheme for the histological description of pistil and fruit.

For meaning of terms consult synopsis No. 722 and moreover 355, 356, 360—366, 369—371, 388—393.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. ovary.
2a. wall, if necessary taking into account exo-, meso-, and endocarp, sarcocarp, ribs and valleculae.
3a. epidermis.
4a. epidermis of outer side.
5a. epidermal cells, including those arising from dilatation growth.
5b. stomata. See guiding scheme No. 71.
5c. idioblasts.
5d. appendages of the surface. See guiding scheme No. 88.
4b. epidermis of inner side. See 4a.
3b. ground tissue.
4a. thin-walled parenchyma, taking into account dilatation tissue.
4b. collenchyma.
4c. sclerenchyma.
4d. idioblasts.
4e. internal glands. See guiding scheme No. 73.
4f. endodermis.
3c. meristeles.
4a. pericycle.
5a. elements of the above.
4b. vascular or fibrovasal bundles. See guiding scheme No. 74 or 75.
2b. dissepiments. See 2a.
2c. placentae. See 2a; moreover conductive tissue.
2d. columella or carpophore taking its origin:
3a. in the dissepiments.
3b. in the style (including peripheral bands).
2e. mode of dehiscence.
1b. style.
2a. epidermis. See 1a, 2a, 3a; moreover conductive tissue and stylar canal.
2b. ground tissue. See 1a, 2a, 3b.
2c. meristeles. See 1a, 2a, 3c.
1c. stigma.
2a. epidermis.
3a. epidermal cells. See 1a, 2a, 3a.
3b. ground tissue. See 1a, 2a, 3b.
3c. meristeles. See 1a, 2a, 3c.

No. 85. Guiding scheme for the histological description of the ovule.

For meaning of terms consult synopsis No. 358, 359, 367.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. funicle.
  - 2a. epidermis.
  - 2b. ground tissue.
  - 2c. meristeles.
- 1b. ovule proper.
  - 2a. atropous (orthotropous) ovule.
    - 3a. nucellus.
      - 4a. epidermis.
      - 4b. ground tissue with chalaza.
      - 4c. embryo-sac.
        - 5a. endosperm.
        - 5b. archegonia.
        - 5c. egg cell.
        - 5d. synergidae.
        - 5e. antipodal cells.
    - 3b. integuments and micropyle.
      - 4a. outer integument with exostomium.
        - 5a. outer epidermis.
        - 5b. ground tissue.
        - 5c. meristeles.
        - 5d. inner epidermis.
      - 4b. inner integument with endostomium. See 4a.
    - 3c. pollen chamber.
      - 4a. outer epidermis.
      - 4b. ground tissue.
      - 4c. inner epidermis.
  - 2b. anatropous ovule. See 2a. Moreover the raphe is to be described here.
  - 2c. hemianatropous ovule. See 2b.
  - 2d. campylotropous ovule. See 2a.
  - 2e. camptotropous ovule. See 2a.

No. 86. Guiding scheme for the histological description of the seed.

For meaning of terms consult synopsis No. 400—418.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

In the first place it ought to be determined which kind of ovule has given rise to the seed.

Micrography.

- 1a. funicle.
  - 2a. aril.
- 1b. seed-coat.
  - 2a. seed-coat proper.
    - 3a. layers produced by the outer integument.
      - 4a. outer epidermis.
        - 5a. epidermal cells.
        - 5b. stomata. See guiding scheme No. 71.
        - 5c. idioblasts.

            - 5d. appendages of the surface. See guiding scheme No. 88.
         - 4b. ground tissue.
            - 5a. common parenchyma.
            - 5b. idioblasts.
            - 5c. endodermis.
         - 4c. meristeles.
         - 4d. inner epidermis. See 4a.
      - 3b. layers produced by the inner integument. See 3a.
      - 3c. layers produced by the chalaza-region.
      - 3d. layers produced by the nucellus.
      - 3e. layers produced by the endosperm.
   - 2b. hilum. See 2a.
   - 2c. raphe. See 2a.
   - 2d. chalaza. See 2a.
   - 2e. micropyle, arillode, caruncle. See 2a.
   - 2f. operculum. See 2a.
- 1c. nucleus of seed.
   - 2a. albumen.
      - 3a. perisperm.
         - 4a. epidermis.
         - 4b. ground tissue.
            - 5a. parenchyma.
            - 5b. idioblasts.
      - 3b. endosperm.
         - 4a. epidermis.
         - 4b. ground tissue.
            - 5a. parenchyma.
            - 5b. idioblasts.
   - 2b. embryo.
      - 3a. radicle. See guiding schemes No. 69, 70 and 87.
      - 3b. plumule. See guiding schemes No. 69 and 70.
      - 3c. cotyledons. See guiding schemes No. 69, 70 and 82.

No. 87. Guiding scheme for the histological description of the root.

For meaning of terms consult synopsis No. 702—709 and moreover No. 723—729.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

- 1a. root cap (calyptra).
   - 2a. columella.
   - 2b. outer calyptra cells.
   - 2c. calyptrogen or calyptra cambium. See guiding scheme No. 70.
- 1b. epidermis.
   - 2a. epidermal cells.
   - 2b. root hairs.
   - 2c. velamen.
- 1c. cortex.
   - 2a. exodermis.

        3a. primary cork layer.
        3b. sclerenchyma.
    2b. primary cortex layers proper.
        3a. sclerenchyma.
        3b. thin-walled parenchyma.
        3c. aerenchyma.
        3d. internal glands. See guiding scheme No. 73.
        3e. latex vessels. See guiding scheme No. 66.
        3f. vascular bundles. See guiding scheme No. 74.
        3g. idioblasts.
    2c. secondary tissues.
        3a. secondary cork and lenticels. See guiding scheme No. 76.
        3b. secondary vascular bundle tissue. See guiding scheme No. 79.
    2d. endodermis.
        3a. endodermis cells proper.
        3b. passage cells.
        3c. idioblasts.
        3d. internal glands. See guiding scheme No. 73.
        3e. secondary vascular bundle tissue. See guiding scheme No. 79.
1d. stele.
    2a. pericycle.
        3a. primary pericycle.
            4a. thin-walled parenchyma.
            4b. idioblasts.
            4c. internal glands. See guiding scheme No. 73.
            4d. sclerenchyma.
            4e. latex vessels. See guiding scheme No. 66.
        3b. secondary pericycle.
            4a. secondary cork tissue. See guiding scheme No. 76.
            4b. secondary phloem and xylem. To be described with the secondary phloem and xylem (2b, 3b or 3c).
            4c. lateral roots and buds.
            4d. secondary vascular bundle tissue. See guiding scheme No. 79.
    2b. phloem and xylem bundles.
        3a. number and arrangement.
            4a. in all roots.
                5a. monarch, di- up to polyarch root.
            4b. in root branches only.
                5a. isostic branches.
                5b. diplostic branches.
        3b. secondary phloem and xylem either wanting, or if present considered in its relation to the original phloem and xylem bundles.
            4a. secondary tissues wanting.
                5a. phloem.
                    6a. sclerenchyma.
                    6b. phloem proper. See guiding scheme No. 74.
                5b. xylem. See guiding scheme No. 74.
            4b. secondary tissue present.

5a. primary phloem. See 4a, 5a.
  5b. secondary phloem. Parts formed by pericycle or medullary commissures also to be described here.
    6a. produced by the phloem arches of the cambium. See guiding scheme No. 77.
    6b. produced by the xylem arches of the cambium. See guiding scheme No. 77. If consisting only of parenchymatous elements forming a large medullary ray, not to be mistaken for a medullary commissure. See also 5d, 6b.
  5c. cambium.
    6a. phloem arches. See guiding schemes No. 69 and 70.
    6b. xylem arches. See guiding schemes No. 69 and 70.
  5d. secondary xylem. Parts formed by pericycle or medullary commissures also to be described here.
    6a. produced by the phloem arches of the cambium. See guiding scheme No. 78.
    6b. produced by the xylem arches of the cambium. See guiding scheme No. 78. If consisting only of parenchymatous elements forming a medullary ray, not to be mistaken for a medullary commissure. See also 5b, 6b.
  5e. primary xylem. See guiding scheme No. 74.
3c. secondary xylem and phloem present, not considered in its relation to the original phloem and xylem bundles.
  4a. primary phloem. See guiding scheme No. 74.
  4b. secondary phloem. See guiding scheme No. 77.
  4c. cambium. See guiding schemes No. 69 and 70.
  4d. secondary xylem. See guiding scheme No. 78.
  4e. primary xylem. See guiding scheme No. 74.
2c. medullary commissures.
  3a. primary tissue.
    4a. thin-walled parenchyma.
    4b. idioblasts.
  3b. secondary tissue. If present already described with secondary phloem and xylem.
2d. medulla.
  3a. thin-walled parenchyma.
  3b. idioblasts.

No. 88. Guiding scheme for the histological description[1] of the appendages of the outer surface and the surfaces of internal cavities.

For meaning of terms consult synopsis No. 730—738 and moreover 447—450.

General characters (shape, dimensions etc.) should be mentioned in their proper places; for describing them consult guiding schemes No. 7 and No. 8.

1a. subsidiary cells.
1b. trichomes.

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[1] If appendages are unicellular histological and cytological descriptions more or less coincide.

- 2a. papillae.
  - 3a. ordinary papillae.
  - 3b. stigmatic papillae.
  - 3c. capitate papillae.
  - 3d. file papillae.
- 2b. hairs.
  - 3a. ordinary hairs.
    - 4a. ramification.
    - 4b. uni- of pluricellular.
    - 4c. uni- or pluriseriate (twin hairs).
    - 4d. file hairs.
  - 3b. balance hairs.
    - 4a. number of cells.
    - 4b. file balance hairs.
  - 3c. stellate hairs.
    - 4a. number of cells.
    - 4b. file hairs.
  - 3d. clinging hairs.
  - 3e. collecting hairs or brush-like hairs of style.
  - 3f. stings or stinging hairs.
    - 4a. large conical cell.
    - 4b. socket.
  - 3g. capitate hairs.
    - 4a. not glandular or ordinary.
      - 5a. unicellular.
      - 5b. pluricellular.
        - 6a. basal part.
        - 6b. stalk.
        - 6c. head.
    - 4b. glandular.
      - 5a. ordinary.
        - 6a. unicellular.
          - 7a. cuticular bladder.
        - 6b. pluricellular.
          - 7a. basal part.
          - 7b. stalk.
          - 7c. head.
            - 8a. cuticular bladder.
      - 5b. type of Labiatae. See 5a, 6b.
      - 5c. type of Compositae. See 5a, 6b.
      - 5d. colleters. See 5a, 6b.
  - 3h. root hairs.
    - 4a. rhizoids.
    - 4b. rhizines.
- 2c. haptere appendages.
- 2d. haustoria appendages.
- 2e. epidermal- or trichome emissaries.
- 2f. bristle trichomes.
  - 3a. awn or beard.

    - 2g. prickle trichomes.
    - 2h. scurves or scales.
        - 3a. ordinary.
        - 3b. ramenta.
    - 2i. paraphylls.
    - 2j. indusia of sori.
    - 2k. paraphyses (uni- or pluricellular).
        - 3a. cystids.
        - 3b. periphyses.
- 1c. emergences.
    - 2a. bristle emergences.
    - 2b. prickle emergences.
    - 2c. fruit-pulp emergences.

BOOK III.

RESULTS OF THE APPLICATION OF THE METHOD OF PEN-PORTRAITS IN PHYTOGRAPHY AND A FEW CASES OF ITS APPLICATION IN OTHER SCIENCES.

CHAPTER I.

Applications in Phytography.

I am happily able to give a certain number of examples showing that by the method of Pen-portraits noteworthy results have been gained in several directions in free as well as in applied science. Dealing with these examples in chronological order I find the descriptions of the vegetable drugs in the fourth edition of the Pharmacopoea Neerlandica; Dr. H. H. Janssonius's Micrography of Woods; Dr. J. C. Schoute's investigations concerning the secondary growth of thickness in Palm stems and Dr. Jeswiet's distinguishing of Sugar Cane clones; moreover the work entitled: Moll and Janssonius, Botanical Pen-portraits.

§ 1. The description of the vegetable drugs in the fourth edition of the Pharmacopoea Neerlandica.

In the year 1899 a permanent commission was instituted by the Dutch Government, charged to make yearly a project for completion or modification of the Pharmacopoea Neerlandica and to make, as often as necessary, a project of a new edition of the same.

In its very first session the commission passed a resolution to begin at once with a project for a fourth edition without giving a supplement to the third.

As Professor of Botany at the University of Groningen I was also charged with Pharmaceutical Botany, so that, becoming as I did, the only botanical member of the commission, it became my task to write the articles on vegetable drugs 1). I thought that this task would not be difficult, because in the third edition, which had appeared in 1889, the articles concerning drugs had been written by Prof. C. A. J. A. Oudemans of Amsterdam, my teacher, while I was a student, and I thought that a few alterations would suffice to bring his work up to date. But at the period of undertaking my work, the method of Pen-portraits was zealously studied in the Botanical Laboratory at Groningen, and thus it is no wonder that the question was put in how far this method could perhaps be used with advantage in the descriptions of the new Pharmacopoeia. It was answered affirmatively and of course this meant that the work of the third edition was to be done again. In total I described one hundred and fourteen drugs for the fourth edition.

When the government as has been the case in all civilized countries,

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1) The article on Gallae was by an accidental mistake, written by one of the more pharmaceutical members.

takes care that there shall exist a Pharmacopoeia for being a guide to medical men as well as to pharmaceutical chemists, this means a valuable measure for the protection of public health. The patients will be sure to receive medicines prepared from materials answering to modern scientific claims. On the other hand physician and chemist, if some unhappy consequences should ensue after the use of a certain medicine and they have followed the prescripts of the Pharmacopoeia, are protected by the very same circumstance, and of course this will be especially the case of the dispensing chemist, who has no responsibility beyond that of preparing the medicine. His is so to say the central responsibility, the Pharmacopoeia is his manual and he must be able to control with its help the qualities of all substances, drugs included, which he uses for preparing the medicines prescribed by the physicians. For chemical articles this is a relatively simple matter, but for drugs it is not so easy. In France this circumstance has deprived the drugs in the Pharmacopoeia of any descriptions whatever, and this means that if some mishap occurs, the judges must examine every particular case for itself, consulting experts, and the Pharmacopoeia cannot protect the chemist. The Pharmacopoeia Helvetica is somewhat in the same predicament, the drugs being provided only with some indications hardly deserving the name of descriptions.

The stand point of France and Switzerland seems however not to be the right one. In most countries more or less detailed descriptions of the drugs appear, and this is right, because the adage "prevention is better than cure" must be held in esteem especially in the circles of physicians and dispensing chemists.

Of course the Pharmacopoeia must contain for this purpose descriptions of them, and tending to completeness in this respect means tending to greater safety. On the other hand however, the dispensing chemist is often more or less overtasked and can in no case give much of his time in judging a set of drugs received from his furnisher before they are distributed over the receptacles, from which they are taken for use. Long descriptions are therefore to be avoided and especially descriptions whose control can only take place by means of complicating manipulations, like for instance working with the microscope. The question therefore becomes whether it is possible to attain sufficient results with the help of somewhat restricted Pen-portraits, and this proved indeed to be the case. Organographical descriptions proved in all cases to suffice, and anatomical characters may be added if macroscopic, but ought to be carefully avoided if necessitating the making of sections for the microscope. The German Pharmacopoeia and our fifth edition contain however here and there some of them, but this is no advantage.

Of a certain number of drugs powders occur in trade and the commission resolved that the microscopy of those powders should be added to the articles in question. This microscopy however does not take up much time, as no sections are to be made, and the powder is only to be mixed with some liquid medium on a slide.

The description of these powders was based on the following plan of a strictly practical character. Every description begins with mentioning the elements which constitute the principal mass of the powder, descending gradually to those which are less important. The results of the examination concerning amylum are always mentioned, even in those cases when the substance is wanting or only present in insignificant quantity. Such negative indications were considered necessary in this case, because mixture of amylum with a powder can easily have occurred, so that every doubt ought to be excluded.

It is a thing of rare occurrence that it can be shown ad oculos that the method of description as followed in the fourth edition of the Pharmacopoea can give excellent results with respect to the establishment of the identity of drugs. A very good example of this kind was procured by the description of a powder of *Folia Digitalis*. Before explaining this case, I have to mention that the drug called *Folia Digitalis* consists only of the leaf blades, whilst the petioles are expressly defended, so that the occurrence of petioles in the powder is thereby excluded, and may take rank as a slight falsification.

The case which we have in view here, was the following. I received a sample of the powder of *Folia Digitalis,* somewhat paler coloured than another by which it was accompanied, the latter being considered as a pure standard powder and proving indeed to be so. Investigating the paler powder, it appeared that in the main it did agree with the description of the fourth edition, but that nevertheless spiral vessels and reticulate vessels were present in such numbers, that according to the system of description mentioned above, they could not have been named in the very last place, as was the case in the Pharmacopoeia. There were also found pitted vessels and collenchyma and because these are not mentioned in the complete description of the Pharmacopoeia, their presence was illegitimate. Thence it was obvious that there had taken place a mixture not allowed by the Pharmacopoeia, of powdered petioles with the powder of the leaf blades. Five minutes sufficed for gaining this result, using only those data presented by the Pharmacopoeia. Afterwards it was communicated to me that not for any falsification, but for an experimental purpose petioles had been ground together with leaf blades — not stems, which would have given still another result under the microscope. 1)

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1) If a man wants information from a native of Java concerning something, which is known to the latter, he must take care to ask his question in a general way without adding any supposition, because if he does so, the native being excessively polite, will doubtless answer that the questioner's supposition is the right one, even if this should have neither rhyme nor reason.

Some men consulting a physician will not tell him all particulars concerning their illness and will be prompted to this by various reasons, although none of these may be sensible.

In the same way I have found that men, asking a scientific advice concerning matters of practice have sometimes a very strong tendency to remain silent with respect to all which was known to them of the matter in hand, and which would often have prevented much superfluous work. In the text this was indeed not the

The description of the drugs with the help of the method of Pen-portraits in the fourth edition of the Pharmacopoea Neerlandica is far from perfect and can not be so, because the method was still growing during the work, whilst the appearance of the fourth edition could not be postponed. But a serviceable beginning was certainly made and it might be hoped that a fifth edition would present a welcome opportunity for improvement. This would have been doubtless the case, if I had been able to take care of the drugs in that edition, which did appear in the year 1926. But by my enfeebled eyesight I was prevented from remaining a member of the commission and moreover it proved that there were strong objections, especially among the dispensing chemists, members of the commission, who represented in this respect no doubt a very large number of their colleages in my country. It was therefore determined with an overwhelming majority that in the fifth edition the description of the drugs would be shortened. This has indeed taken place and anatomical characters have indeed been added here and there. The force of the method of Pen-portraits is clearly proved by the fact that in many respects the descriptions of the drugs in the fifth edition still make the impression of belonging to the same genus. The erasions are often modest and the punctuation, which is an important factor in Pen-portraits has remained unaltered. Thus the fifth edition has become a gallery of mutilated Pen-portraits, impoverished in some traits, enriched with superfluous traits in other cases.

The reader who desires to know more particulars concerning all this may be referred to a paper, which I published in the year 1916 [1]). It is certain that among dispensing chemists there existed at the time a conviction that Pen-portraits were too long for the Pharmacopoeia, but I have never met with good arguments for proving the truth of this conviction, so that I remained in uncertainty with respect to the foundation of this conviction and at present I am still in the same predicament.

I hope that a time will come in which Pen-portraits of drugs will again appear in the Pharmacopoea Neerlandica, and for this purpose its fourth edition will offer a solid starting point.

§ 2. The description of Wood Anatomy with the help of the method of Pen-portraits by Dr. H. H. Janssonius.

In the year 1906 there appeared from the botanical laboratory of Groningen the first part of a serial publication, which was continued during many years and is now approaching its completion. It was the description of a great collection of wood samples belonging to the investigations of Dr. S. H. Koorders concerning the trees of Java.

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case, because the matter was so very simple and clear. But in general it was my custom before beginning the work to ask the questioner in the first place for communication of all particulars whatever and however insignificant concerning the things about which information was wanted.

[1]) J. W. Moll, De beschrijvingen der Simplicia in de Nederlandsche Pharmacopee. Een probleem van toegepaste wetenschap. Pharmaceutisch Weekblad 1916, No. 42 en 43.

The reader can find a detailed description of this work of Koorders and all about it in my Introduction to the "Mikrographie des Holzes" 1), but nevertheless the importance of the matter makes it necessary to insert here a short historical account.

Melchior Treub, the renowned Director of the Botanical Garden called "'s Lands Plantentuin" at Buitenzorg, among many other plans projected a careful study of the tree flora of Java, of which a great part grows in the primeval forests, so that this flora is a most difficult but also a most important subject from a botanical, as well as from a practical point of view. Thence in the year 1888 Dr. S. H. Koorders of the Forest Department, stimulated by Treub, commenced to collect materials for a tree flora of Java. This collection took place with consummate skill and foresight. More than 4000 trees, for a considerable part growing in the primeval forests, were each provided with a board, on which this individual tree was marked by letters and figures. A system of registers and maps permitted the refinding of every tree which was thus marked as easily as if it had been growing in a botanical garden.

Those trees were visited at stated intervals with a staff of labourers, so that leaves, flowers, fruits and seeds could be had at various stages and a complete herbarium was collected from every marked tree. The wood of the same tree was gathered, either by hewing down the marked tree when the herbarium material was completed, or by taking branches of various thickness. This collection is unique of its kind, and of the herbarium part samples were distributed to several of the great herbaria of the world.

In the year 1892, 15000 specimens had been collected and it now became the question how this material could be described. For this purpose Treub again took the direction and asked Dr. Th. Valeton, then at Groningen, to come to Buitenzorg to write a tree flora of Java. In this respect Dr. Koorder's help was of course indispensable, but yet he was not enough a botanist for bringing so arduous a task to a good end. The combined exertions of Koorders and Valeton led to a voluminous publication of the botanical garden of Buitenzorg, entitled: Additamenta ad cognitionem Florae Javanicae auctoribus S. H. Koorders et Th. Valeton. Pars I. Arbores 1894—1914.

The distribution of the subject matter in this book is by no means first-rate and Dr. Valeton was the first to admit this fact himself, the families having been taken by him at random from the herbarium. The book therefore is not adapted to casual consultation, but its contents are first-rate, the descriptions being explicit and detailed, so

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1) Mikrographie des Holzes der auf Java vorkommenden Baumarten im Auftrage des Kolonial-Ministeriums, unter Leiting von Dr. J. W. Moll, Professor der Botanik an der Universität Groningen, bearbeitet von H. H. Janssonius, im Anschluss an "Additamenta ad cognitionem Florae arboreae Javanicae, auctoribus S. H. Koorders et Th. Valeton" (Mededeelingen uit 's Lands Plantentuin), Publikation des Departements für Landwirtschaft in Buitenzorg, Leiden 1906. In the year 1932 the publication of this work is still going on, although approaching its completion.

that the grades of relationship are clearly and easily to be established.

Thus the herbarium was duly taken care of, but Treub saw very well that the description and especially the anatomical description of the thousands of wood specimens ought also to receive full attention. For this purpose however it was not necessary to summon a young man from Europe; it was much cheaper to send the whole wood collection to Europe to be investigated there. He knew that my attention was strongly directed towards micrography and that Mr. H. H. Janssonius was already working during three years at the description of pharmaceutical drugs, which was many years afterwards published under the title of "Botanical Pen-portraits", of which the reader will find a full description, further on, in the fifth paragraph of this Chapter.

In the year 1903 Dr. Treub therefore asked me whether I was willing to promote and superintend the description of Koorders's wood samples in the botanical laboratory at Groningen. Dr. Treub's offer was accepted, Mr. Janssonius's work on the drugs was suspended, for many years as it proved afterwards, and Mr. Janssonius was charged by the Dutch Department of the Colonies with the description of Javanese woods, at which he is working still.

From the beginning I was convinced that the anatomical description of woods would have a great value from a practical point of view, and would eventually govern the market of tropical timbers and in this respect I was not mistaken, as is proved by the existence of the International Association of Wood Anatomists, of which I am happy to have received the honorary membership. But I was by no means certain that wood anatomy could also have a more theoretical value, with respect to the systematical character of the plants to which the wood belonged. This was however a question which strongly interested Dr. Janssonius and in every familiy dealt with in the "Mikrographie des Holzes", the first paragraph being a summary of the anatomical structure of the wood, the second paragraph was called: results of the anatomical investigation of the wood for the knowledge of the systematic relations within the family.

Dr. Janssonius made a special study of these questions and was able to obtain important results, by comparing what he had found himself before he knew the relationships mentioned in systematical works, with the contents of such works like Engler and Prantl, Durand, Bentham and Hooker and especially the work of Valeton. In many cases he found confirmation of what he had himself deduced from his own descriptions, in other words strengthening of existing views by his new facts; where differences between the views of different systematical authors occurred, he was often able to sustain one of those views by means of strong arguments. These paragraphs form a very important part of his book, for eventually theoretical results concerning the relationship of plants are scientifically more important than the practical side of wood anatomy. They must be considered as not in any way influenced by the method of Pen-portraits, which he was obliged to use. Thus Dr. Janssonius at the same time was able to show by a practical example of large dimension, that the objections, made against the method of Pen-portraits and treated in detail above in the first Book, are indeed valueless.

During his studies concerning the existing literature about Wood Anatomy, Dr. Janssonius soon found that the work of Sanio was not only the most complete, but also the most eminent, in such a degree, that all other publications containing results different from those of Sanio were far inferior to them. Sanio's views are often misunderstood, which may be partly explained by the peculiarities of his manner of writing, but for all that, he was right in the great majority of cases. It may be said that the influence of Sanio's work on the terminology used in the "Mikrographie des Holzes" and dealt with in the Introduction to the book, is paramount.

The work on Javanese woods treated above in detail, is doubtless the most important of the works of Dr. Janssonius and it is sincerely to be hoped that he will be enabled to complete it, notwithstanding the unhappy period of economy, in which we are living at present. Three smaller works of Dr. Janssonius, also applications of the method of Pen-portraits on Wood Anatomy must however be treated here.

In the first place a paper ¹) concerning the identification of five West-Indian woods, which had been brought into the timber market. It was at the request of Dr. A. H. Berkhout at Wageningen that Dr. Janssonius made this investigation. It is perhaps worth mentioning that the families, to which the described woods belong, all occur also on Java; but the five species used by Dr. Janssonius for making his Pen-portraits, belong to five genera which are not represented on Java. There is no doubt that sooner or later the woods of Surinam, with its afforested surface of fifteen millions of hectares will be described like those of Java, and that the great work on Javanese woods of Dr. Janssonius will serve in many respects as an example for those descriptions.

In the second place a paper entitled: "Der anatomische Bau des Holzes der Pfropfhybride *Cytisus Adami* und ihrer Komponente" ²).

Winkler's splendid discoveries concerning graft hybrids had made it very probable that the renowned *Cytisus Adami Poit* belonged indeed to this category of plants. It was of course of the highest interest to study the anatomical structure of this curious plant, as it had not been possible to get an experimental proof concerning such an origin by a renewed union of *Cytisus Laburnum* and *Cytisus purpureus*, which are doubtless its components.

Such anatomical investigations had indeed taken place more than once, for instance by Macfarlene, Fuchs, and Laubert ³), but the results of these authors had been defective in consequence of their

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¹) H. H. Janssonius, Mikrographie einiger technisch wichtigen Holzarten aus Surinam. Verhand. Kon. Akad. Amsterdam 2nd Sect. 18, 2, 1914.

²) H. H. Janssonius und J. W. Moll, Recueil d. Trav. bot. néerl. 8, 1911, p. 333.

³) J. M. Macfarlene, A comparison of the minute structure of plant hybrids with that of their parents, and its bearing on biological problems. Transact. Roy.

want of a good micrographical method. It had of course attracted my attention that the method of Pen-portraits might be singularly adapted for shedding light on his question. In the year 1910 during the flowering period of *C. Adami*, *purpureus* and *Laburnum* I commenced together with Prof. van Slogteren, then my scientific assistant, to describe the anatomy of the flowers, and we soon found that the epidermis of the corolla of *C. Adami* was identical with that of *C. purpureus*, whilst the whole inner part consisted of pure *Laburnum* cells. We considered this as a proof that *C. Adami* is *C. Laburnum*, covered with an epidermis layer of *C. purpureus*, but these investigations were not completed and consequently never published.

On the other hand, Dr. Janssonius, made Pen-portraits of the secondary wood of three branches, all belonging to the same tree of *C. Adami*, one of these branches exhibiting the type of *C. Adami*, the other two belonging to the types of the two components of *C. Adami*, viz. *C. Laburnum* and *C. purpureus*. As is well-known, such recessive branches of both components habitually appear on older specimens of of *C. Adami* and those of the *Laburnum* type often show such a tendency to dominate that they must be removed. These Pen-portraits were published in the paper cited above.

The result of these investigations was that *C. Adami* doubtless possesses *Laburnum* wood. Notwithstanding some differences between its wood and wood of recessive *Laburnum* branches could be detected, these differences were never of such a kind, that the wood of *C. Adami* appeared by them more nearly related to *C. purpureus*.

In the third place I have to deal with a paper called: "The Linnean Method of describing anatomical structures. Some remarks concerning the paper of Mrs. Dr. Marie C. Stopes, entitled: Petrifactions of the earliest European *Angiosperms*" [1]).

In this paper Dr. Stopes gives detailed, anatomical descriptions of three specimens of fossil wood belonging to the collections of the British Museum of Natural History. These specimens are from the Lower Greensand, a formation of the Cretaceous Period and are considered by the author as representing the oldest European *Angiosperms* known up to this date. For this reason a careful study of the interesting specimens was commenced by Dr. Stopes, and descriptions were made, so far as the condition of the specimens permitted. By far the best preserved specimen was that called *Aptiana radiata*, gen. et spec. nov. Dr. Stopes had made of this specimen a careful and detailed anatomical description, as far as this is possible without making use of the Linnean method.

Soc. of Edinburgh. Vol. 32, Part I. p. 203. 1893.

C. A. Fuchs, Untersuchungen über *Cytisus Adami Poit.* Sitzb. d.k. Akad. Wien 107, Abth. I. 1898. p. 1273.

R. Laubert, Anatomische und morphologische Studien am Bastard *Laburnum Adami Poit.* Beih. z. Bot. Centrbl. Bd. 10, 1901. p. 144.

[1]) Published by the Royal Academy of Sciences at Amsterdam. Proceedings of the Meeting of October 26th. 1912. p. 620. This paper was reprinted in: Recueil Trav. bot. néerl. Vol. 9, 1912. p. 452. The paper of Stopes is to be found in: Phil. Trans. Roy. Soc. B. Vol. 203, 1912. Pp. 75—100 and Plates 6—8.

After reading this it occurred at once to Dr. Janssonius that the specimen might belong to the family of *Ternstroemiaceae*, which had been described already by him in his Mikrographie des Holzes. Therefore the description of *Aptiana*, given by Dr. Stopes was transformed, using the same terms, into a Linnean description and then it appeared that *Aptiana* belonged indeed to *Ternstroemiaceae* and must be very nearly allied to the genus *Eurya*, perhaps being a species of it indeed. Thus it was proved that the oldest known specimens of Angiospermous wood did not show a primitive structure, but possessed already all characters belonging to a genus, now still living on the island Java. Therefore we may say that by the method of Pen-portraits we were enabled to establish a fact, not unimportant for Paleontology and Geology.

§ 3. The investigation of the secondary growth of Palms by Prof. J. C. Schoute.

Prof. Schoute published in 1912 his investigations concerning the secondary growth of *Palms* and not only showed that it did exist, but also that it was not the consequence of reiterated cell divisions, as in *Dicotyledons*, but of prosecuted growth in primary cellular elements. This result was reached in fact with the help of the portraying method of description, but before such a description could take place, special difficulties were to be surmounted.

It proved impossible to obtain serviceable transverse sections of thick palm stems, so that the author was forced to content himself with observations of transverse surfaces of thick palm stems, which had been sawn through and were illuminated with lime light under several complicated precautions, which the reader will find fully described in the chapter III entitled "Methodisches" on page 81 of the treatise. By means of this method drawings, some of which had a length of five or six meters, were made. The author then proceeded to make detailed descriptions, partly using the drawings themselves, partly small transverse sections at certain places studied under the microscope.

These descriptions contained all particulars concerning number and distribution of fibrovasal bundles, number and direction of cell layers, dimensions and directions of extension of cells and fibres, thickness and nature of cell walls, characters and dimensions of intercellular spaces; in a word all characters, which were liable to be altered if secondary growth in thickness might take place. Making these descriptions, which indeed show the essential characters of a Pen-portrait, the author writes, that the character and the course of the process of growth in thickness became clear to him without more ado, so that when the descriptions were completed, the solution of the problem was also complete.

We have here a beautiful example of the use of the method of Pen-portraits in a restricted way, only for solving a single limited problem. This kind of use of the method will no doubt remain in future of most common occurrence. For cases like that of Dr. Janssonius, whose scientific investigations necessitate the making for many years of Pen-portraits of a certain special kind, must certainly remain always rare exceptions. Schoute used the method of Pen-portraits in the same way as his microscope, for spying out some things which were not apert of themselves, and this is the Pen-portrait's proper use.

§ 4. Use of Pen-portraits for distinguishing Sugar Cane clones in practical Sugar Cane culture [1]).

Since most clones of Sugar Cane used in practical culture are obtained by cross breeding, often from the same parents, many of them resemble each other so much, that they sometimes are mixed up in practice. This mixing up of clones of different qualities and different worth took place on such a large scale, that big losses resulted. Good differential characters were needed to undo these mistakes. Such characters were discovered at the Experimental Station of Pasoeroean in Java, Netherlands East-Indies.

The Experimental Station in Pasoeroean was under the direction of Dr. Ph. van Harreveld who studied several years in the Botanical Laboratory at Groningen. He was convinced that, using what we now call the portraying method and the guiding schemes belonging to it, it must be possible to discover serviceable differential characters on the vegetative plant material, which is used for propagating Sugar Cane. So he requested Dr. J. Jeswiet, then botanist at the Experiment Station, to describe the clones of Sugar Cane cultivated on Java in such a way that identification should always be possible of not-flowering stems. The latter was necessary because the plant material of Sugar Cane on Java is taken from plants which are too young for flowering, and also because flowering in many clones is rare.

The results did not fail to appear soon. Specially the buds and leaf sheaths were described, because they bear a great number of hair groups, each with their own topography. The papers of Dr. Jeswiet and afterwards of three other authors, concerning these subjects, have appeared in the "Archief voor de Suikerindustrie in Nederlandsch-Indië", commencing in 1916. Afterwards this method of description for obtaining differential characters of clones was adopted in Argentine, Japan, Cuba and other cane growing countries. In this way many losses were avoided, preventing the mixing up of similarly looking clones by the use of the portraying method of description.

§ 5. Moll and Janssonius Botanical Pen-portraits.

This work has already been mentioned above in § 2, where I told that Dr. Janssonius had worked in the Laboratory at Groningen for three years before he commenced his "Mikrographie des Holzes" and that these investigations were then suspended for many years, so that the publication was delayed until the year 1923. This work can only be considered as an application of the method of Pen-portraits in another sense than the investigations dealt with in the preceding paragraphs. It was not written with the object of solving some problem with the help of the method of Pen-portraits like the works mentioned above, but only as a contribution to Pharmaceutical Botany, chiefly in the anatomical direction, to show how descriptions made with the help of the method of Pen-portraits ought to be written, so that they can procure complete satisfaction to those who consult them.

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[1]) The following notice was written in cooperation with Dr. Ph. van Harreveld.

The inhabitants of a small country with a language of its own, such as the Netherlands, are heavily handicapped in their scientific pursuits by the necessity of using a foreign language. It was my wish that this book should be written in English, although I knew that Mr. Janssonius was better able to write in the German language. Experience having shown to me that writing a book in the Dutch language and afterwards translating it is for various reasons a bad plan, Dr. Janssonius at once commenced to write in English as well as possible, hoping that the necessary corrections could be made afterwards. In a certain measure this happened indeed, but after some years the condition of my eyes necessitated seeking for other help. In the "Botanical Pen-portraits" on p. 16, the reader will find how a new impulse was given to the work by my successor Prof. J. C. Schoute and how Miss Ledeboer and afterwards Mrs. van Eck-de Wiljes contributed to the completion of the work.

CHAPTER II.

APPLICATIONS IN OTHER SCIENCES.

§ 1. Applications in Medicine.

Dr. Hymans van den Bergh, formerly Professor of Medicine at Groningen, now at Utrecht, after attending a lecture of mine concerning the method of Pen-portraits, drew my attention to a book of Adolf Strümpell entitled: "Kurzer Leitfaden für die klinische Krankenuntersuchung," Leipzig 1912. This book may be considered in some respects as an application of the method of Pen-portraits to the examination of patients by a physician, for a previously stated order of sequence in the description and guiding schemes corresponding to it, form the foundation of this book which certainly has no botanical origin. It can doubtless be very useful in its way and can help physicians of middle quality talents to obtain the same results in determining the characters of a disease, as can be obtained without these means only by a few men of a certain genius. It is no pons asinorum with which it may be confused only by those, who do not understand what the method of Pen-portraits really is.

Medical students in their first year, follow at Groningen botanical exercises of microscopy, founded as will be set forth in the fourth Book of this work on the method of Pen-portraits in its most simple form. These students soon end their botanical studies and therefore it is difficult to obtain a fair judgment concerning the influence of such studies on the physician in after life. But I have reason to suppose that in some cases at least the effect of Pen-portraits in the making of diagnoses has been noticeable.

§ 2. Applications in Prehistorical investigations.

Dr. A. E. van Giffen whose work concerning giants' graves, terps as places of refuge in former times and other prehistorical phenomena is generally known, began his scientific career as a student of Botany in the Laboratory at Groningen. In this quality he became of course acquainted with the method of Pen-portraits during his anatomical exercises and he proved at once to be an adept. Prehistorical studies however soon absorbed his whole attention and in these he applied the principles of the method of Pen-portraits in such a way as this was possible.

In the year 1927 an excursion during two days was led by him through the Province of Drenthe, in such a way that at the end of it he received from the French Government the order of the Légion d'Honneur. After Dr. L. Capitan, Professor of American Archeology in the Collège de France at Paris, had awarded the order, he was heard to say with a slightly affected voice: "I have now for the first time made the acquaintance of a fine methodical prehistoric investigation", and this judgment had involuntarily led Dr. van Giffen's thoughts towards the time of his exercises in the botanical laboratory at Groningen.

§ 3. Applications in Genetics in the domain of Zoology.

The late Mr. S. A. Arendsen Hein at Utrecht conducted beautiful genetical researches with *Tenebrio molitor* (meal-beetle and meal-worm), which were alas prematurely interrupted by his lamented death in the year 1925. After a very successful career in Dutch East India he had preferred to return to his native country instead of aggrandizing his wealth, and to use his time in philosophical and biological studies, for the latter of which he proved soon to possess a singular fitness and perseverance. He made use of seven different strains of Tenebrio and it was of paramount importance for him to be able to distinguish at once and with certainty the larvae of his seven races. He told me that this was a matter of great difficulty to him and I expressed my conviction that good descriptions were all that he needed for this purpose.

I told him of the method of Pen-portraits and I brought him so far that he conceived the plan to make them, althoug he saw at once that it would be a thing of great difficulty. At first he was quite unable to find his way and it was only with great pains and heart-breaking that he persisted in his plan. The problem was indeed rather difficult, for of course guiding schemes, the plumb-lines of Pen-portraits, were not at his disposal, although he could very well have made them afterwards. After many hours of heavy work he was however able to make very good descriptions and henceforth he could distinguish his larvae easily at first sight, which seemed to me a little triumph of Pen-portraits.

It is not the place here to go into more details concerning Arendsen Hein's investigations, and in this respect I refer my readers to a dissertation written by Dr. F. P. Ferwerda [1]), under the auspices of Prof. T. Tammes in the Genetic Institute of the University at Groningen. Prof. Tammes had shown a strong interest in Mr. Arendsen Hein's investigations and had given him much good advice, and after the death of Mr. Arendsen Hein his widow asked Prof. Tammes, if she would receive in her Institute all materials, instruments, etc., which her husband had left behind. This proposal was accepted and Mr. Ferwerda choose this subject for his dissertation. He finished investigations which Mr. Arendsen Hein had left incomplete behind him, and moreover added interesting further researches of his own.

§ 4. Applications in colonial politics and other colonial concerns by Dr. N. R. Pekelharing.

At first sight it might seem somewhat strange that relations of this kind have existed, and it is indeed to a curious juncture that this relation is due. To understand this, it is necessary to take into account the principal circumstances in the development and life of the late Dr. Pekelharing and therefore I will try to sketch them briefly.

N. R. Pekelharing in his early youth wished already to go to India and to seek a place in the plantations. His father, a Professor of Pathological Anatomy and afterwards of Human Physiology in the University at Utrecht, approved of his plans, but premised that in order to make a good career he should begin with making his studies at the University. This was certainly quite right and in after life his son has frankly admitted it. But it soon became apparent that the mentality of the young man was of a decidedly practical turn, even somewhat fidgety, in such a measure that he was averse from purely scientific work and lacked all interest for scientific investigations. He commenced his university studies at Utrecht and after having carried there the grade of Candidate, he came to Groningen in order to take his examination for the degree of Doctor in Botany and Zoology, crowned by writing a dissertation on a botanical subject. Botany being his principal subject he followed of course from the beginning practical exercises in the Botanical Laboratory and after his examination he spent there all his time in writing his dissertation.

The subject of it was a systematical investigation concerning the anatomical structure of the leaf-blade in the family of *Theaceae* [1]), and it was chosen, because he was destined to get a place at a tea plantation on the island Java of which one of his relatives was the proprietor. My readers will understand that during the whole time of his practical occupations in the Botanical Laboratory the method of Pen-portraits was playing an important part in his work, although it was by no means always to his taste. In a letter from Dutch East India in the year 1923 he writes that when during the first months at Groningen he sat sighing behind his microscope he did not think it possible that he afterwards would see the importance of it very plainly, notwithstanding it is so natural to apply this method to any other subject whatever.

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[1]) F. P. Ferwerda, Genetische Studien am Mehlkäfer Tenebrio Molitor L. Genetica. Nederlandsch tijdschrift voor Erfelijkheids- en Afstammingsleer. Vol. 9, 1929. p. 1. This paper was published in the year 1928, as a dissertation of the University at Groningen.

[1]) N. R. Pekelharing, Systematisch-anatomisch onderzoek van den bouw der bladschijf in de Familie der *Theaceae*. Dissertation Groningen 1908.

During his stay in India there were two periods in which his use of the method of Pen-portraits and especially of its guiding schemes became particularly clear. After having been entrusted during some years with the administration of a tea plantation and having brought it into good order, he thought that he could do work of more importance and became Head of the Division of Agricultural Economy at the Department of Agriculture, Commerce and Industry.

At that time many complaints were heard about the heaviness of taxes in the cultures and it was always said that in this respect foreign colonies were more attractive. The Governor-General Fock wished to receive information about the truth of these assertions, and thus Dr. Pekelharing was charged to visit three foreign colonies: the Straits Settlements, English Borneo and French Indochina. For this purpose two higher functionaries were directed with Dr. Pekelharing to make an instruction for this task.

This seemed of course at first not easy, even very difficult till Dr. Pekelharing made a proposal. He had revolved in his mind, in reminiscence of the period at Groningen in the Botanical Laboratory, what things had to be considered when he arrived in a foreign colony, and he had made a regular guiding scheme of the questions which ought to be answered. The two other gentlemen saw at once that those guiding schemes must lead to good results, so that they were promoted to his instruction.

After having made his trip, the Straits seven weeks, British Borneo eighteen days and French Indochina eight weeks, he delivered a splendid report [1]) to which the reader is referred and which gives a complete survey of the existing circumstances in the several Colonies, based on an objective research and fit to be a guide for future measures to be taken by the Government.

The second period, in which the use of the portraying method and its guiding schemes proved to be useful, followed afterwards. When he had been for several years in Government service, he preferred to seek for a place in a first-rate particular concern, and he was happy enough to find this at once. He became adviser for the mountain cultures in a powerful private concern: Internationale Crediet en Handelsvereeniging Rotterdam. This concern possessed plantations of India-rubber, tea, coffee, Cinchona, Theobroma Cacao and capoc. In this function, when visiting a plantation, he made also use of guiding schemes to the construction of which the advice of Dr. Ph. v. Harreveld, himself a user of the method of pen-portraits, had contributed.

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[1]) Departement van Landbouw, Nijverheid en Handel. De groote cultures in Nederlandsch-Indië en eenige naburige Koloniën. Dr. N. R. Pekelharing, Hoofd van de Afdeeling van het Departement van Landbouw, Nijverheid en Handel. Verslag naar aanleiding van een in opdracht der Nederlandsch-Indische Regeering ondernomen reis naar het Schiereiland Malakka, Britsch-Noord-Borneo en Fransch Indochina voor het maken van een vergelijkende studie omtrent de voorwaarden, welke in die landen en in Nederlandsch-Indië voor het vestigen van landbouwondernemingen worden geboden aan vreemd kapitaal. Landsdrukkerij Weltevreden 1924.

§ 5. Applications in Zoology.

Hodie desunt; cras abundabunt.

BOOK IV.

EDUCATION IN PHYTOGRAPHICAL METHODS.

During a long course of years, first in my function as a teacher of Natural History in secondary schools at Utrecht during fourteen years, afterwards in my function of Professor in Botany at the University of Groningen during about thirty years, a certain part of my task consisted in educating young men in the art of phytography. I was always strongly interested in this portion of my work and I may say that the results of it have been brought together in the present volume. Considering these facts it seems but natural that a section dealing with education in this direction should appear here, and I trust that my readers will permit me to treat this subject in more detail than could be warranted for the principal purposes of the present book.

The method of Pen-portraits is at present the most complete of phytographical methods. We have seen that it comprises not only the ordinary Linnean method of description, but also the application of it to anatomical investigations, which we have called Micrography and moreover is supplemented by those more casual personal observations without technical terms though in telegram-style, which give to the description a more portraying character. Teaching the method of Pen-portraits in its completeness means therefore teaching all that is known at present concerning Phytography, and it is clear that every botanist in future must understand it and must be able to make use of it. In this respect it is equivalent to Microscopy, although in other respects there may be great differences.

Every botanist in our time must have a certain ability of working with the microscope, although of course not every one of them can be a first class microscopist and many an investigator in the ordinary course of his work may use only a small part of his time in working with the microscope. There are even several very able botanists, who do not like the instrument and work with it only from sheer necessity; but to work with it now and then all are compelled. For the rest it is evident with regard to the relation between Microscopy and Pen-portraits that this is of a casual and by no means of a causal nature: microscopical observations being used in a Pen-portrait only where things are too small for being observed with the naked eye, and this is of course the case in the majority of anatomical investigations, both cytological and histological.

§ 1. Use of Pen-portraits.

The necessity of microscopical observations being thus circumscribed, the use of Pen-portraits on the other hand is not in the same predicament. It might be supposed that with its help the whole plant kingdom ought to be described, so that every investigator would find at his disposal a complete fund of morphological knowledge to serve him in his work.

We will see however that this is not the case because the execution of such a plan would meet with the same obstacles which prevent astronomers determining the velocities of all fixed stars individually. My lamented friend, Prof. J. C. Kapteyn, often told me that in the present state of science it would remain only possible to determine a velocity of certain groups of fixed stars, because the labour wanted for the determination of these velocities is so enormous, that time and men were wanting for such an undertaking.

The introduction of the method of Pen-portraits has created an obstacle of the same sort against the production of a complete phytography of the whole plant kingdom, as mentioned above.

For understanding this I may refer the reader to a very interesting paper of Alphonse de Candolle [1]), written in the year 1873, in order to celebrate the completion of the Prodromus Systematis Naturalis Regni Vegetabilis, the famous work commenced by Augustin Pyramus de Candolle and finished by his son Alphonse and his grandson Casimir. We find in this paper rather complete information concerning the history of the origin of the Prodromus and the many difficulties encountered during its growth, chiefly from the often occurring unreliability of members belonging to the staff of collaborators, so that the labour was made a trying one for the nervous system of the authors.

A. de Candolle further deals with the characters and difficulties of future works like the Prodromus, called by him "ouvrages généraux".

When Augustin Pyramus was occupied with writing his Systema[2]), he was able to describe in a single year one thousand species, say three a day. He saw however that this progress was too slow for completing his work in a reasonable time, and he therefore resolved to write a less extensive work, which he termed "Prodromus". When he commenced this the number of species was heightened to ten a day, but Alphonse, writing for the same Prodromus, was compelled to be contented with a single species a day. He moreover supposed the existence of a tendency towards greater slowness, firstly from the general growth of science and moreover he was of opinion that anatomical facts must be mentioned in future Phytography.

Now it is clear that the introduction of the method of Pen-portraits must cause an enormous lengthening of the time necessary for making a single phytogram. I can attest that a complete pen-portrait of a higher plant will easily take a man's work during a whole year. Moreover the number of known species has enormously augmented since A. de Candolle's time, and that of *Siphonogama* alone has grown to 150,000. Thousands and thousands of lower plants must be added and so we are certainly not above the mark, if we say that the completion of a work comprising the Pen-portraits of all known plants would cost at least 150,000 years of a man's work. In other words it would be a sheer impossibility; with 1,000 collaborators it would still take 150 years. The reader will see at once that the only alternative is that every botanist should be able to make a Pen-portrait when he wants it for his special investigations.

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[1]) Alphonse de Candolle, Réflexions sur les ouvrages généraux de botanique descriptive. A l'occasion du dix-septième et dernier volume du Prodromus qui vient de paraître. Archives des sciences de la bibliothèque universelle Genève.

[2]) Regni vegetabilis systema naturale sive ordines, genera et species plantarum secundum methodi naturalis normas digestarum et descriptarum. Auctore Aug. Pyramo de Candolle, Paris, Vol. I 1818; Vol. II 1821.

In our standard works of Systematic Botany we must be contented with a grade of details like that of Engler und Prantl's "Pflanzenfamilien" or "Das Pflanzenreich". Pen-portraits will remain personal concerns of botanical students, mere private transactions, like working with the microscope. And because no descriptions of the utmost completeness can become available within a reasonable time, it is clear that every botanist must receive a solid education in this art as well as in Microscopy.

Phytography is at least in my country not only teached at universities, but in a certain measure also in secondary schools and gymnasia. I cannot omit to deal with this question somewhat in general. In my opinion there is a by no means imaginary danger of overburdening the syllabuses of these schools with subjects, unripe for their pupils. But the Organography of the higher plants as being the basis of Botany and the Anatomy of the human body being the basis of Zoology, do not belong to this category. The Organography of the higher plants is a subject quite ripe for such intermediate schools. It has been studied for several centuries and has become a superb teaching instrument in the hands of a man such as Linné, not inferior to mathematics, languages etc. I have taught it for years without ever using a book, but giving repeated short dictations during the lessons. In the two lowest classes of these schools the Organography was treated with some intensity, so that at the end of the second year the pupils were able within a single hour to write a good Linnean description or diagnosis of a higher plant and afterwards to determine its name with the help of a small Flora. In summer, exercises of this kind were held in the higher classes. When leaving the school my pupils had obtained a solid basis of botanical knowledge, which could not have been better if they had received instruction for becoming botanists in future; just as reading, writing, ciphering etc., are taught to all children in the same way, independent of the question, whether they are to become in later life field-labourers or scientists.

But when I became a Professor of Botany at the University of Groningen in the year 1890 I found soon that the majority of the students did not possess a botanical knowledge like that sketched above. After some years I wrote a small manual of Phytography 1) destined for my botanical students, and moreover for teachers of Natural History and intermediate schools. In its Introduction the

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1) J. W. Moll, Handboek der Plantbeschrijving. 1st ed. Groningen 1900, 2 ed. 1912. 3 ed. 1916.

reader will find a very complete account of what I told above concerning my work in this respect, written however in the Dutch language. The book is now out of print and I have mentioned before how its subject-matter, of course without the Introduction, has been reprinted for the botanical laboratories of Groningen and Utrecht (see p. 28 footnote).

Of small importance here for us is the fact that of late years in my country Botanical Anatomy, combined even with microscopical exercises, has been introduced into some intermediate schools. This seems a grave mistake, for our Anatomy is not yet possessed of any of the advantages exhibited as we have seen by Organography, and will remain for a long time an unfit instrument of instruction for intermediate schools. For the present it ought to be restricted to the Universities.

It is clear that for teaching the art of making Pen-portraits at the University, practical exercises are indispensable. There is however a great difference between those exercises destined for teaching the construction of organographical Pen-portraits and those destined for teaching the anatomical branch of Phytography. The organographical exercises are comparatively simple; I shall deal with them in the next paragraph. The anatomical exercises on the other hand are always far more complicated as will be explained in our third paragraph.

§ 2. Organographical exercises.

Practical exercises of this kind, as they are now conducted at our Universities do not take into account of course the organographical part of my Synopsis, which has been published for the first time in the present work.

In the existing botanical literature the desirability of special guidance for practical exercises of the organographical kind has not often been felt and I am acquainted with two examples only. The late Professor Suringar of Leiden wrote a Pocket-Flora 1) for the Netherlands in the year 1870, for special use in the secondary schools which had been newly erected. Of this excellent work there appeared a great number of editions, eight of them under the care of the author himself. In the introduction of the eighth edition (1895) which lies now before me, Suringar gave for the first time some directions for making a description. He knew of course very well that for a schoolboy it is a sheer impossibility to use a Flora for determination with advantage if he has not beforehand made a description of the plant in hand.

I experienced the same during fourteen years of teaching in secondary schools at Utrecht, so that no disciple was permitted to try determination of a plant before its description was ready. Suringar chiefly produced his directions in the shape of an example, giving a rather

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1) W. F. R. Suringar, Zakflora. Handleiding tot het bepalen van de in Nederland wildgroeiende planten in aansluiting met de werken der Nederlandsche Botanische Vereeniging, Leeuwarden 1870.

complete Linnean description of *Veronica Chamaedrys L.* A guiding scheme was not given. This was however produced by myself in the year 1916 in the third edition of my school-book (Handboek der Plantbeschrijving), already mentioned above on p. 22 and 28.

After Suringar's death his Pocket-Flora was reprinted more than once, successively by the care of Dr. A. J. M. Garjeanne, Dr. H. J. Calkoen, Dr. L. Vuyck. These editors with the exception of Dr. Garjeanne left out Suringar's description of *Veronica Chamaedrys* and refer the reader for the question of phytography to my school-book, cited above [1]).

The foregoing considerations lead to the conclusion that the practical exercises, as they now exist at Groningen and Utrecht on the basis of my school-book, must be altered and brought into conformity with the Synopsis of General Morphology in the present volume. To make the organographical part of a Pen-portrait becomes then a rather simple thing. On consulting the part dealing with guiding schemes in the second book the student must choose out of the sixty schemes concerned with organography those which can be of use in the construction of the projected Pen-portrait. He then can begin at once and the matter is at an end, no additional guidance being needed.

§ 3. Anatomical exercises of Cytology and Histology.

We might call them as well micrographical, using this term in the sense defined in the first Book, where the application of the Linnean method of description to Micrography was explained.

These exercises in consequence of various causes exhibit a rather complicated character, even so much so that it is necessary to answer in the first place a question on which I have not dwelt when dealing with organographical exercises, because it was superfluous there. With respect to Micrography however it is necessary to fix beforehand what a practical exercise properly is, because at Universities the term is often used for what might be better called demonstration lectures. I will use the term practical exercises only for those cases in which the student is not merely receptive, but plays an active and independent part in the proceedings. He must be charged with a task for which the necessary materials are put at his disposal, but he must think out and perform the work himself, be it under a certain control.

But medical students for instance are often required to attend so-called practical exercises in which their activity is reduced to a minimum, because they receive sections of animal tissues, prepared beforehand by officials of the Laboratory, fixed and dyed, whilst the students only mount them on slides. They could as well receive those slides ready made; using the students for this work is only necessary in order to unburden the officials. But the execution of such a simple manipulation, moreover instantly followed by explanations by the Professor or a scientific assistant, does not promote them to the rank of practical exercises in the proper sense of the word: independent manual and headwork of the student must remain the principal feature of practical exercises, although we will see that the authors of manuals destined for those exercises have sometimes forgotten this fundamental truth in a curious way.

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[1]) Calkoen, tenth edition p. 31 and Vuyck, thirteenth edition Groningen 1920 p. 1. both in a footnote.

The above is only a preliminary consideration and I will now show in what respects micrographical exercises are more complicated than those of the organographical type. For this purpose I may refer the reader in the first place to a paper by my hand entitled "Die Fortschritte der mikroskopischen Technik seit 1870" [1]), which was written in the year 1907, and we may safely take for granted that since this date the art of Microscopy has become even more complex. In this paper the reader will find summed up all that is needed for the art of Microtechnics: workroom, microscopes, microtomes, methods of fixation and dyeing, imbedding, whetting of knives and razors, plasmolytical method of De Vries, heating method and dissolving method of van Wisselingh, etc. etc.

The above is sufficient to complicate micrographical exercises, but it is not all. In dealing above with the application of the Linnean method of description to Micrography (p. 9), we have seen that in many cases, using sections of the same object in different directions, empirical descriptions arise which must be united together into perspective descriptions, and that moreover those perspective descriptions ought to be arranged into a topography and cell descriptions as has been set forth loco citato.

It is clear that micrographical exercises in consequence of what has been said above, exhibit a complication much greater than that of the organographical exercises, and now there is a circumstance, not occurring with respect to the organographical, which is apt to complicate micrography still more. This is the fact that whilst organographical work is well nigh restricted to botanical students, micrography is not only a subject of the highest importance for botanical students, but also for medical and pharmaceutical, and it is evident that what these three categories want in Micrography is in many respects very different. Thus we find that three different kinds of micrographical exercises appear in the botanical laboratory:

1. Propaedeutical exercises for medical students in the first year of their study at the University. It is an indisputable fact that medical men in their future sphere of action ought to possess an elementary familiarity with the use of the microscope and it is as indisputable that this can only be procured by using botanical objects. It is only in this way that they may become really able for studies of Human Histology in the course of their further medical education.

These practical exercises are of the lowest grade and may be attended also by pharmaceutical students in their first year.

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[1]) "Progressus rei botanicae" redigiert von Dr. J. P. Lotsy, Bd. II. Heft II, Jena 1908.

2. Practical exercises for pharmaceutical students, who have proceeded so far that they must become acquainted with the anatomical structure of vegetable drugs.

3. Practical exercises for educating botanical students. These exercises usually are kept apart from the beginning. The propaedeutical exercises mentioned above under 1 must remain limited to those subjects which are absolutely necessary and this would lead to a certain undesirable superficiality in botanists, who ought by all means to form as solid a foundation as possible with respect to the art of Microscopy. Their education ought to possess moreover not a classical but on the contrary a decidedly individual character.

What the method of Pen-portraits in its fulness can give for results in botany, will be shown below in some carefully worked out examples, and it is to be hoped that future botanical literature will bring many more of the same kind. But it would be premature, if I should try here to go more into details on this head. On the other hand however I can show at present with certainty the results of the propaedeutical micrographical exercises of the lowest grade on a basis of the method of Pen-portraits.

These exercises were held every year from the beginning of October till the middle of May, with two interruptions corresponding to holidays of some weeks at Christmas and Easter. I am not far from the mark when I say that about twenty-five practical exercises could take place within this space of time, so that the reader may keep in mind that we have to do here with a modest piece of work. On the other hand this work and especially the preliminary examination called "tentamen" took place under a rather high pressure, because a satisfactory result of the last practical exercise, considered as a tentamen, set the student free from verbal examination and procured him indeed the certainty that his Botany would be reckoned sufficient. For an example I have chosen the work of a student Mr. B., made on May sixteenth 1913, in about two hours, which was indeed the ordinary space of time for these exercises.

The task given out was the following: *Tilia platyphyllos Scop.*, young stem, alcohol material. Make transverse sections and mount them in glycerin after treatment with iodine dissolved in potassium iodide. Describe the sections and make a topographic sketch with the camera lucida.

Description. Epidermis cells oval to rectangular. R ± 20 μ, T ± 10 μ. Walls thin 1—3 μ, cuticle 5—7 μ. Contents mostly shrunk together and become brown.

Cortex. Under the epidermis a layer of secondary cork-tissue, 50 μ thick. It is initial-celled cork in radial rows, alternating with the cortex proper. Phellem consisting of periderm, layer ± 20 μ thick, cells rectangular R 5 μ, T 10 μ, cell walls thin, having become brown, transverse walls with rather large simple pits. Phellogen, also thin-walled consisting of two layers of narrow cells. Phelloderm consisting of some layers of thin-walled cells, together a layer of 15—20 μ. Cells more square than those of the phellem. Cortex proper.

Collenchyma consisting of 3—5 layers of roundish cells, forming a layer of ± 50 μ. Often not only the angles, but also the tangential walls thickened. Common parenchyma, forming a layer 50 μ thick. Cells large, stretched out in a tangential direction and often provided with one or more radial partition walls so that several cells have been formed. In many places the parenchyma has disappeared. Idioblasts present as crystal-idioblasts with crystal clusters, filling the whole cell. Endodermis indistinct, but probably having existed as an amylum-sheath. Still to be found as such against the sclerenchyma of the phloem. Not against the large medullary rays. The cells oval-rectangular T 30—40 μ, R 15—20 μ. Walls somewhat thickened. Opposite to the large medullary rays the cells of the endodermis strongly divided by radial walls.

Stele. Pericambium, one cell layer thick, or wanting. Cells a little smaller than those of the endodermis. Opposite to the large medullary rays strongly divided in a tangential direction. Primary phloem indistinct, strongly compressed, separated from the pericambium by a sclerenchyma, at most five cell layers thick (inner sclerenchyma cells smaller than the outer). Secondary phloem consisting of sieve tubes with companion cells with distinct contents. Vessels about 10—15 μ in diameter, companion cells 3 μ. In the young phloem in tangential rows bundles of cells with thicker walls than the rest. In the older phloem they are grown out into sclerenchyma. They are probably bast-fibres. Moreover in the phloem there are present parenchyma cells. The companion cells lie on the radial side of the vessels. The cells of medullary rays are in the older part much stretched in a tangential direction and have formed transverse walls [especially the cells of the large medullary rays]. In the younger parts stretched radially. The cells adjoining the phloem contain amylum. The cambium consists of 3 layers of thin-walled cells. Secondary xylem consisting of vessels, especially lying in the spring wood, 30—40 μ, and smaller cells ± 10 μ. Bordered pits especially on the transverse and tangential walls. Cells of medullary rays strongly stretched in a radial direction. T 6—8 μ, R 20—30 μ. Primary xylem up to 60 μ thick. Medulla consisting of circular to polygonal cells. Idioblasts smaller and much larger cells.

The topographical sketch cannot be reproduced here; it was of course provided with an explanation.

Transverse sections, description and topographical sketch were all three considered as "excellent". It was the best work of this year, but the work of three only out of the 33 was considered as insufficient.

It is clear that such a result proves that the method used in our practical exercises was a good one; they were conducted at that time wholly by Dr. Tine Tammes, at present Professor of Genetics at our University. The description reproduced above is not perfect, but it shows that the student was able to handle the microscope and having attended two lectures a week dealing with anatomy, he was further able to analyse and describe the rather complicated internal structure of the stem of *Tilia*. His description was however only empirical and he had not learned to combine three or more of these in order to get a perspective description. But for all that his knowledge of Microscopy was amply sufficient for his medical or pharmaceutical studies.

We have seen that books, written with the purpose of helping students in their organographical exercises, exist only in a small number, but the reader will not be astonished to find that for practical exercises concerning anatomy, a very large number of such books does exist. Not one of them however is really complete, and taking into account the complexity of subject-matter as sketched above, this is very natural and moreover it is not wanted and it seems preferable that according to the wants of the students, books of different kinds are available, as indeed is the case.

Seeing how large the number of subjects is which may be wanted in works of this kind, it seems incredible that several authors have by no means shunned to insert in their handbooks great masses of material not at all wanted there and frequently even interfering rudely with the use for which the work was really written. Thus Dippel 1) in his excellent manual uses the second volume chiefly for morphological descriptions exhibiting especially an anatomical character. They must be considered as indeed harmless but totally superfluous additions to Dippel's manual, because they can be found more detailed in every good text-book of Botany and ought not to be used in the course of practical exercises, because they should be known beforehand to the student engaged in his work.

In many manuals however there are to be found detailed descriptions of the material in hand which ought not to be brought to the knowledge of the student during his work. What would be said of a Professor or assistant in chemistry who, conducting a practical exercise, did not only give to his students samples of the substances destined for qualitative or quantitative analysis, but at the same time would give them the results, which they ought to obtain. It is clear that such a proceeding would in fact destroy the whole which must of course only be considered as an exercise of really independent scientific work for the student.

In Botany however things of this kind daily occur. In the manuals of Micrography we find of course for every exercise a special subject mentioned, a plant or some part of it. But several authors of these manuals add to it a description and often also a figure, which the student should make himself from his own observations. As an example I may cite Strasburger, Das botanische Praktikum, of which seven editions have appeared and which is indeed a valuable work from many points of views. But its detailed descriptions form its very weak side.

A student of Botany is naturally a man with all the failings belonging to man and there cannot be ascribed to him the strength of mind for postponing the lecture of the descriptions and the examination of

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1) L. Dippel, Das Mikroskop und seine Anwendung, Brunswick Two vol. 1867—1869.

the figures till he has made both for himself. If he did so he could perhaps learn something useful, although indeed the descriptions are written in a rambling non-telegram style, as if Alphonse de Candolle's "Phytographie" had not been already published in 1885 [1]). The end is that students using this manual will begin with studying what Strasburger has said concerning the object, instead of studying in the first place the sections they made themselves, and therefore generally they take no special cares for obtaining good sections.

In the Laboratory at Groningen the use of Strasburger's book for these experiences is considered as injurious for practical exercises, and the three editions of it which the Botanical Laboratory ownes and which are often used for their other good technical qualities, are kept under the guardianship of three assistants who take care that students cannot use those descriptions and figures when they are at their ordinary practical work.

Some persons have uttered their fear that the working method recommended in the present book is too difficult, and that it is worth while to buy the interest of students by allowing them a certain laziness. But this opinion is defended only by those who are not good teachers and are unable to interest their pupils for a more rigorous proceeding; nevertheless it is not so very difficult to do this and in the end the students will be grateful for it.

Beyond Strasburger's Praktikum there are several other manuals, exhibiting more or less the same fault and it is superfluous to mention their titles. Nevertheless there is one most curious example entitled: "Atlas de Botanique microscopique, Manuel de Travaux pratiques [2]), which deserves to be noticed. As the footnote may explain it is largely used at Paris and on its 135 pages it contains nothing but beautiful plates, each showing a certain number of figures accompanied by their explanations; so that its only contents consist of things which ought not to be shown to the students while they are busy with their exercise. As far as I know this is the only example of a work containing nothing of importance for the student using it, but exclusively that which according to rational views, ought to have been kept secret for him and actually spoils the whole business.

I now proceed in connection with what has been told already above, to give a more complete general sketch of the way in which the micrographical exercises were conducted in the botanical laboratory at Groningen.

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[1]) I can recommend the reader to transpose a long description of Strasburger's book into a Linnean description, taking care that not a single character should be omitted, then to count the number of letters in both descriptions and he will be astonished at the difference.

[2]) Atlas de Botanique microscopique, Manuel de Travaux pratiques. A l'usage des Candidats au Certificat des Sciences Physiques, Chimiques et Naturelles (P.C.N.), à la Licence ès-Sciences Naturelles (Botanique et Physiologie générale) et des Elèves des écoles d'Agriculture, des Ecoles de Pharmacie, des Ecoles de Médecine, des Ecoles de Commerce, de l'Enseignement secondaire, des Ecoles coloniales, des Ecoles normales, etc. Par Henri Coupin, Docteur ès-sciences, Laureat de l'Institut, Maître de Conférences adjoint à la Sorbonne, Henri Jodin, Docteur ès-sciences, Docteur en Médecine, Assistant de Botanique (P.C.N.) à la faculté des sciences de Paris, André Dauphiné, Docteur ès-sciences, Chef des Travaux pratiques de Botanique (P.C.N.) à la faculté des sciences de Paris. Avec 54 Planches. Troisième édition revue et augmentée. Paris 1930.

Tradition. It has always been my conviction that verbal tradition, if necessary combined with the exhibition of objects and instruments, ought to play a considerable part in the education of university students in the Laboratory. Traditions have been developed in almost all directions of human society: in the Army as well as in Churches of all creeds, in the theatre, the circus, Plastic Arts and Music, in plant- and cattle-breeding, in industry and commerce, in household and kitchen, and it is handed from generation to generation by verbal communication, exhibition and example, not by printed books, which will in such respects always remain insufficient.

The Botanical Laboratory forms by no means an exception; tradition appears in all practical exertions. Therefore tradition has always played a prominent part in the education of students by means of practical exercises under my direction, and this can only be the case where particular pains are taken for preliminary verbal explanations at the beginning of the practical work.

Thus in my time it was my custom to precede a certain number of the first propaedeutical exercises by short explanations in the lecture room, in order to give some verbal directions regarding the task performed in those first exercises which chiefly consisted of technical manipulations. Botanical students were kept apart from the propaedeutical exercises mentioned above. Their number being not very large, they received constantly verbal explanations of all kinds, so that tradition became a strongly developed factor in the botanical laboratory at Groningen, as it is in many other laboratories. I am sure that at present it is well nigh impossible to become a good microscopist only with the help of handbooks, and without being in some measure acquainted with tradition as it is preserved in good botanical laboratories.

Redaction of descriptions. The definitive redaction of an organographical Pen-portrait will cause in most cases no special difficulties. If a good guiding scheme has been used, a precise wording may in most cases be attained by insignificant retouching.

The redaction of anatomical Pen-portraits however is a process of much greater complexity, as may be deduced from what has been told before. In the first place the empirical descriptions must be combined together into perspective descriptions. Further, topography and cell descriptions must be arranged as seems best for every case, and all this ought to be retouched till a satisfactory whole appears.

Manuals. For technical questions of several kinds Strasburger's Praktikum was much used. Bolles Lee's Vade-Mecum 1) I have always considered as indispensable for students who wish to make a special study of microtome work, imbedding and dyeing methods and all things in this direction. It is a most valuable book.

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1) A. Bolles Lee, The Microtomist's Vade-Mecum. A Handbook of the methods of microscopic Anatomy, London, 3 ed. 1893; 6 ed. 1905.

For paraffin imbedding a paper in Dutch, written by myself and entitled: "The application of paraffin imbedding in Botany" ¹), was generally used.

Two other papers by my hand concerning the whetting of microtome knives ²), were also used.

But a special manual fit to be a general guide during the practical exercises of medical, pharmaceutical and botanical students did not exist in the year 1890, when I entered upon the botanical Professorate at the University of Groningen. Thus I was obliged to help myself and this chiefly took place in such a way that every student received at the beginning of every practical exercise the necessary directions for doing his work, reproduced by means of a cyclostyle. In this way I proceeded during seventeen years, continually improving the method, and after the lapse of so many years, I had gathered abundant materials for writing myself the book which I wanted and which might perhaps be of service to others. It was written in Dutch and entitled: "Handboek der botanische Micrographie" ³). The contents of this book consist in the first place of an introduction concerning the general tenor of the work, from which in a certain sense the present work has developed, so that it may be considered as not very important for my present readers.

The first section deals with instruments, reagents, also with the treatment and preservation of the necessary plant material.

The second section is entitled: the scientific analysis of microscopic structure, and deals with the application of the Linnean method of description in Micrography, the use of guiding schemes, the empirical and perspective description, and lastly with the use of drawings in their relation with descriptions.

The third section forming the principal part of the book contains the tasks for the several exercises, destined for the student's use during his work. These tasks are 489 in number, of the most various kinds, and fit not only to be used in their propaedeutical studies by medical and pharmaceutical students, but also for botanical students during the whole course of their education at the university. In the latter respect the reader's attention must be drawn to the numbers

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¹) J. W. Moll, De toepassing der Paraffine-Insmelting op botanisch gebied. Maandblad voor Natuurwetenschappen, No. 5 en 6. 1887.

²) J. W. Moll, Het slijpen van Mikrotoom-messen. Dodonaea 1891. p. 541. The same: Das Mikrotom Reinhold-Giltay. Zeitschr. für wissensch. Mikroskop. Bd. 9, 1892, p. 445.

³) J. W. Moll. Handboek der botanische Micrographie. Ten gebruike bij de practische oefeningen voor aanstaande medici, pharmaceuten en biologen. Groningen 1907. Mentioning in the text some particulars concerning this book the reader is referred to this first edition. About the year 1925 the first edition was exhausted and a second was provided by my successor Prof. J. C. Schoute. Because the book had never been used in any other laboratory, some parts were left out as being sufficiently known in the laboratory of Groningen.

Moreover it was impossible to reproduce the alphabetical register in its full extended shape. For these reasons readers, wishing to know the book in its full extent, must consult the original edition. The title of the book remained unaltered, there was added only: Tweede Druk, bewerkt door Dr. J. C. Schoute.

252 to 348, entitled special exercises taken from literature. They are destined for more advanced botanical students and I have chosen for them treatises of the best order, to be considered as more or less classical, because I was of opinion that to repeat in all particulars such work cannot fail to be useful. Evidently however such exercises may in a certain sense be considered as not deserving the title of practical exercises, because the student is by no means independent in his work and the results he will obtain are offered beforehand to him, ready made, in all particulars. But all other exercises of whatever kind, cytological, histological, systematical, etc. have in common that the results to be obtained by the students making use of them, are kept concealed and never mentioned even by a single word, so that the student is forced to do his work himself.

Lastly mention must be made of a peculiarity in the alphabetical register at the end of the work. In many cases it will be very important for students to learn where they can find some special anatomical and other particulars clearly demonstrated. By means of copious annotations made before the book was written, I was enabled to include in the register the numbers of those practical exercises offering the particulars sought for, although they are not mentioned in the tasks themselves. Vascular bundles (amphicribral, amphivasal, bicollateral, collateral, concentric, closed, open, radial, ending of them, monocotyledonous arrangement, secondary), epidermis (remaining, upper with few stomata, upper without stomata, secondary growth, strongly thickened outer walls, strongly thickened walls, undulated side walls), hairs (balance-, stings, unicellular, emissaria, internal, glandular, crystal-, of stamens, pluricellular unbranched, pluricellular branched, collecting hairs of style, file-, root-), etc. etc., may serve as examples. Because the work described here was written in the Dutch language and no translations of it did appear, its use was limited to my country, but here it did not meet with any success, for, as we have seen above, the Botanical Laboratory at Groningen was the only one, in which it was habitually used or exerted some real influence.

BOOK V.

THE DISTRIBUTION OF THE SUBJECT MATTER IN TEXT-BOOKS.

CHAPTER I. INTRODUCTION.

In Chapter II of the first Book of the present work I explained how the terminology for building up a Synopsis of General Morphology was brought together by carefully studying a certain number of good text-books. This proved to be a plan of some importance, for it gave rise to considerations, which have been brought together in this fifth Book and which are concerned with the history, the present state and the future of Botany. It may be said that good text-books give a somewhat complete representation of the Science at it is seen by the author, and consulting subsequent text-books we will be able to get an insight into its historical development.

I am well aware that there are many scientific men of a more matter-of-fact nature, who will have not the slightest interest for the construction of a botanical text-book, a subject which will be dealt with in this section. Their attention is so fully absorbed by the palpable and real contents which a good text-book can afford, that there is no attention at disposal for extending towards the distribution and arrangement of the subject matter in such a book. Men of such a kind are of very general occurrence and no doubt several authors of text-books themselves belong also to this category. Such men perusing text-books as I did, with the purpose of collecting technical terms for Phytography, would needs have been led to the same simple criticisms which occurred to me, but they would have considered them as a worthless refuse, unfit for being dealt with in any respectable work on Phytography, certainly by no means as an interesting by-product, worthy of being accommodated with a place in the present work.

My own mentality however is more of a theoretical character. Every year when opening my course of lectures I used to give a somewhat encyclopaedical general introduction into Botany. I was convinced and have remained so, that a good preliminary division of the subject matter is not only useful for a better scientific appreciation, but also may show the way to disciples destined to become in their turn promotors of science. Although this subject for many years captivated my attention, it was very well known to me that the majority of botanists do not partake of my strong interest concerning distribution of material, which led me in my youth even to unjust appreciation about the literary value of novels I was reading.

But if some of my readers cannot partake of my opinion which certainly is their good right, I advise them to place this last part of the present work on their index capitum prohibitorum, an advice which cannot fail to be efficient, because there is no interest in their mind which could prompt them to sinful curiosity.

The consequence of the foregoing considerations therefore is that I offer to my readers a critical study with respect to the construction of some text-books, not all new ones and quite up to date, but still belonging in principle to the present period of botanical science. I believe to be able by a careful study of them to show the causes of their principal faults and to show the way for mending these faults in future, which would mean emendation of Botany itself, the foundation of all text-books.

I will try to prove that in course of time two mistakes have been made in the construction of our text-books. The first is that Organography is not treated as a whole, but separately for the principal divisions of the natural system, although at first sight it may seem that it is otherwise.

A second mistake concerns the position of Anatomy, which is generally considered as properly belonging to Physiology and not as exhibiting narrow relations with systematical Botany. The latter mistake is however not of such importance as the first one concerning the splitting up of the Organography according to the groups of the plant kingdom.

By and by I understood that in text-books we have to do with the outcome of a complex of interesting historical events, concerning the development of the Botanical Science. Only by taking these events into account, the failures which at present botanical text-books as a genus doubtless exhibit, can be explained and corrected. It is therefore certainly worth while to take a view of these matters in connection with a wider point of view. For attaining this end I must begin with a somewhat lengthy historical chapter and it is only after this that I will be able to proceed in a third Chapter to a critical consideration of several text-books.

CHAPTER II.

HISTORICAL CONSIDERATIONS.

§ 1. The development of Biological Science in the nineteenth century.

The historical events mentioned above of the nineteenth century consisted of an overwhelming development of biological science, only to be compared with the revolutions which have taken place of late in Physics and Mathematics.

The wonderful and many-sided development of technics which began in the preceding century and is still going on in all directions, must certainly be considered as a foundation on which a diversity of scientific investigations could be built.

The microscope from a home-made instrument was promoted into an instrument of precision, culminating in Abbe's beautiful discoveries. Microtomes of all kinds were invented; both instruments became accessible to all University students. Flemming introduced fixation of protoplasm and imbedding methods, and the improvements in the manufacture of dyes exerted their influence [1]). Physics and chemistry produced many methods and apparatus, which could be of the utmost importance in biological investigations.

In this period, and in many respects by the exertions of Julius Sachs and several of his disciples such as Hugo de Vries and Pfeffer, the physiology of higher plants after a long time of more casual and quasi latent growth expanded its wings, building forth on the results produced by the work of de Saussure, Senebier, Hales, Ingen-Housz and others.

Anatomical researches comprising cytology and histology, chiefly conducted with the help of the microscope, were published in large numbers and were often brought into contact with physiological investigations. A connection with Malpighi's and Nehemia Grew's anatomical researches in the seventeenth century is certainly existing, although far less intimate than that between the work of Sachs and that of his predecessors.

Microscopical observations brought also to the light structure and development of many lower plants. As examples may be cited: the life history of *Secale cornutum,* described by Tulasne (1850); that of *Fucus* by Thuret (1852); those of *Vaucheria, Oedogonium, Saprolegnia* and *Coleochaete* by Pringsheim [2]) (1855); those of *Puccinia Graminis* and other *Fungi* by De Bary (1860); the interesting symbiosis exhibited in *Lichens* by Schwendener (1870), and last but not least the foundation of Bacteriology by Pasteur.

By such a staff of scientists a splendid chapter, treating the Morphology and Taxonomy of the lower plants, was added to Botanical Science.

Completing this sketch of the principal botanical discoveries during the nineteenth century, three illustrious scientists must be mentioned here: Hofmeister, Alexander Braun and Darwin.

Hofmeister published about the year 1850 his splendid discoveries concerning the special form of polymorphism called at present alternation of generations, which by subsequent cytological studies have expanded into a solid foundation for the taxonomy of the whole Vegetable Kingdom. Hofmeister's work in this direction is perhaps the most important discovery of the preceding century in Systematic Botany. A beautiful disquisition of this subject has been offered by Julius Sachs in his History of Botany [3]).

Alexander Braun, another German botanist of worldwide reputation, living in the same period and perhaps most generally known by his researches on Phyllotaxy, published a few years later an elaborate paper entitled: "Das Individuum der Pflanze" [1]. Although my conception of the term plant-individual may not agree with that of Braun, I consider that his beautiful essay contains materials highly important with respect to alternation of generations, a term for the first time used in Botany by him. But it is impossible to deal with this subject here and I must be content with mentioning at this place that Braun's succession of shoots ("Sprossfolge" or "Sprossverkettung") has been worked out in a somewhat modified shape and has found a prominent place in the synopsis of General Morphology in the second Book of this work. For this subject the reader may be referred to the articles S. No. 7 and S. No. 241 of the synopsis.

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[1]) J. W. Moll, Die Fortschritte der mikroskopischen Technik seit 1870. Progressus rei botanicae. Band. II. p. 228. 1908.

[2]) During my stay at Würzburg in Julius Sach's Laboratory he told us during one of our excursions how Pringsheim had assured him that without the then newly invented, now generally used revolver of the microscope, he could not have made his researches concerning *Algae.*

[3]) Julius Sachs, Geschichte der Botanik vom 16. Jahrhundert bis 1860, München 1875, p. 214.

Charles Darwin published his Origin of Species about eight years afterwards and it is a fact that his theory of natural selection by survival of the fittest still governs in Biological Science.

Summing up we must say that the progress of Biological Science during the nineteenth century was enormous and indeed it may be called overwhelming, in such a measure that misunderstandings of several kinds could not fail to arise.

It is now my task to give a historical sketch of the assimilation of the new materials in the body of Biology. I will do this in the first place by consulting my own experiences which extend over a period of about sixty years. I think that thereby the reader can be supplied with a good insight into the difficulties which were met by young biologists in the latter half of the nineteenth century, when the wonderful progress of Biology was culminating.

§ 2. The Darwinian Theory of Natural Selection.

Beginning with the Darwinian theory we may state at once that objections against this theory are often heard in our days. They may be of such a kind that it is superfluous to treat them here in detail, because the controversies to which they lead, can only be brought to a decision on theological or metaphysical battle-fields, which I may avoid, because I am speaking here only from the point of view of modern physical sciences. Thus the theories of creation, teleology and the like may be left out of account here.

On the other hand however we hear also strong objections from scientists who in all respects participate in the usual views of modern physical science and such objections ought to be treated here somewhat in detail. These objections are all raised on the simple ground that Darwin has not given what he promised, namely that he has not explained all complicated adaptations, like eye, ear, poison-fangs of snakes[1]), etc. How is it possible that such an assertion can be regarded as a valid objection by so many men?

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[1] A. Braun, Das Individuum der Pflanze in seinem Verhältniss zur Species, Generationsfolge, Generationswechsel und Generationstheilung der Pflanze. Abh. d. Kön. Akad. der Wiss. Berlin 1853.

For every well-educated person, though not specially versed in Biology must know that special and complete explanations for phenomena of this kind have never been offered and that it will probably take a long time, perhaps many centuries before mankind can hope to possess anything, like such information. They may also know that Charles Darwin was not the man to endow us with so unfulfillable promises. But it is true that in scientific circles the same unreasonable claims are still often brought forward and this fact is certainly the origin and at the same time the excuse for laymen who hold such views. Oscar Hertwig, Boveri, Hanstein, Nägeli and even Warming may be cited as examples, and for more particulars, the reader is referred to article S. No. 5 of the synopsis. How is such a state of affairs to be explained?

Consulting my own reminiscences of some sixty years ago, I find that about the year 1868 being still busy with learning Latin and Greek, but having already a hang towards Biology, I read during my holidays a Dutch translation of Darwin's Origin of Species, but I could not understand it, so that only a very slight, superficial and confused impression of the theory remained.

A few years later in 1873, being then a student of Biology at the University, I resumed my Darwinian studies by reading Haeckel's Natürliche Schöpfungsgeschichte in its fourth edition, and then I thought that I could understand Darwin's theory very well. There were indeed several drawbacks in what I then learned and from the beginning Haeckel's inconsiderate materialism belonged to their number, so much the more because it was a quite superfluous factor. But in other respects light dawned for me on Darwin's theory, however mixed up with darkness. I did not see that the title of the book: "Natural history of creation" (Natürliche Schöpfungsgeschichte), contained already a promise which could not be kept, for the term creation as used by Linné, designates an act of the Creator, inexplicable by what we call natural phenomena, and when we wish to make use of the latter we ought to speak of Evolution. I further concluded that variation, struggle for life and survival of the fittest could not be denied, so that the whole matter lay in a nut-shell and difficulties like eyes, ears and poison-fangs, although they might not be explicable at once, would become so by and by. I could not see that Haeckel's book was in many respects superficial, but there were others who saw it and in many heads a strong reaction took place and strong expressions of it followed.

It seems probable to me that Haeckel and his school have caused the lamentable misunderstandings concerning Darwinism, which still are flourishing. I think that some, and among them good biologists, having been first fascinated like I was by Haeckel's views, became wiser afterwards and then renounced at once the whole Darwinian theory, thus pouring out the child with the bath.

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[1]) Th. Boveri, Die Organismen als historische Wesen, Festrede der Universität Würzburg 1906.

But I will show that there is also place for a reaction against Haeckel in a more modest and moderate form, and eventually I think that I may say like I began, that Darwinism is still a dominating theory in Biology.

Now returning to my own experiences I mention that some years later, being in function as a teacher of natural history at the secondary school of Utrecht, I read the Origin of Species again, now in the English language. My mind was now riper and fitter for understanding this beautiful book and my views concerning natural selection became more moderate, so that I could see the theory as it is, as fundamental in Biology, a sound basis for investigations of many kinds, but not reaching very far with regard to the explanation of particular cases. In its light important problems may be raised and and sometimes explained to a certain extent.

Being so far improved in this respect in the year 1890 I held an inaugural oration, having been appointed as botanical Professor at the University of Groningen. It was entitled: "The influence of Darwin's theory of descent upon Botany" 1), and it showed somewhat in detail how this theory had cleared up our views in all departments of Botany, and that in my opinion it must be used freely in teaching Botany at the University. During thirty years in my lectures and practical instruction I was able to keep the promises given in this oration and I may truly say that during this period nothing has been altered in my general views, concerning the Darwinian theory.

§ 3. The relation between Morphology, Physiology and Taxonomy.

Further pursuing the train of my personal experiences I come to another question, less important in a general way but much nearer related to Phytography. It is the connection between Morphology, consisting of Organography (external organization) and Anatomy (internal organization), with Physiology and Taxonomy. It is no wonder that when as I will show, veteran botanists and writers of well-known text-books were too strongly under the impression of so many inventions and new thoughts, young men just coming into science might be quite captivated by all these interesting methods and views and that some confusion and perplexity should be the result in their mind.

I was one of them for I began my botanical studies in the year 1870. With respect to the connections existing between Morphology, Physiology and Systematic Botany, my mentality and that of many other young men was strange and inconsistent. On one hand I was firmly convinced that Anatomy, comprising Cytology and Histology belonged to Physiology, which was the study of my choice like it was

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1) J. W. Moll, De invloed van Darwin's afstammingsleer op de Botanie, Redevoering bij de aanvaarding van het Hoogleeraarsambt aan de Rijks-Universiteit te Groningen, Groningen 1890.

that of many other young men, and this connection was absolutely predominant in my mind. On the other hand however, I could not fail of course to know many things clearly proving that anatomical facts could also have a high importance in taxonomic questions, but all things of this kind existed only outside the circle of my special attention and at all events could not influence the questions which then specially absorbed my attention.

For more than twenty years this state of mind remained unaltered. As has been mentioned above Schwendener's Mechanische Prinzip and Haberlandt's Physiologische Pflanzenanatomie have produced a terminology of their own, mixed up with so many theoretical conceptions that it is lacking the objectivity wanted for a general Phytography, such as has been worked out in this book. But Schwendener's investigations at that time made a strong impression on my mind and it appeared to me that something like Haberlandt produced afterwards should be preferred to the principles then generally applied in dealing with Anatomy. I was reprimanded at once by a senior student, who told me that in taxonomy "pure Morphology" was the only trustworthy guide and believing that this was true, I concluded that Anatomy ought to be strictly reserved for use in Physiology.

Thus for many years I came out with physiological Anatomy on all occasions offered to me, though they might not be very numerous at that period of my career, and I did so to my own content and perhaps also to the content of not highly critical hearers. Such views then possessed at all events a certain novelty. In my oration on Darwinism cited above, I stated on p. 8 that the knowledge of external and internal shapes and conditions is of course very important for both physiology and systematic Botany, but that there were two different branches of this knowledge, one which was then called "Morphology" destined for systematic Botany, and the other called "Anatomy", belonging to Physiology.

When in 1880 the first edition of the text-book of Oudemans and De Vries was published, I was fully convinced that anatomy ought to be dealt with in the first volume, written by De Vries and treating physiology. Some other examples may show the same conviction and at the same time its internal contradiction.

For instance Pfeffer's and Engelman's investigations concerning the connection of colours and carbon assimilation and the oecological phenomena of *Algae* growing at various depths of the sea, absorbed my full attention. I knew very well that the names *Chlorophyceae, Melanophyceae, Rhodophyceae* and *Cyanophyceae* existed, but my attention was absorbed in such a measure by the physiological side of the matter, that the idea of a possible taxonomic power of anatomical facts such as variously coloured plastids, did not rise in my mind.

As another example I may mention my position with respect to the fact that *Gymnospermae* exhibit a secondary xylem without vessels, but the taxonomic importance of this phenomenon did not attract my attention. At the same time I was however strongly interested in the physiological side of the matter with respect to Godlewski's views concerning the part played by living cells in the motion of water through the stem. These considerations led afterwards in the Laboratory of Groningen to the researches of Reinders [1]), but the systematic side was at that period totally neglected in my mind.

As a young Professor soon after the year 1890, I unduly attacked on a Doctor Promotion, a young gentleman who maintained in a thesis that the chemical composition of plants could be an important factor in taxonomy. If the discussion could be resumed now I would offer him my apology and tell him that concerning this subject my opinion and that of many other botanists, has since been thoroughly altered.

I was by no means converted at once to a better insight, but by and by I received in my own Laboratory, impressions which brought me to other opinions.

In 1908 Prof. Tine Tammes [2]) published an investigation concerning the dispersion among the higher plants of Dipsacan, a chromogen, Dipsacotin, a blue colouring matter and Dipsacase, an enzyme; all three discovered by her. These substances occur in all *Dipsaceae* which were investigated, embracing the following genera with the number of examined species, noted behind them: *Dipsacus* 12, *Succisa* 3, *Scabiosa* 11, *Knautia* 6, *Asterocephalus* 4, *Pteridocephalus* 1, *Trichera* 1, *Cephalaria* 14. The genus *Dipsacus,* which was the starting point of these researches is the richest in Dipsacan, but among the great number of species belonging to other genera, there was not a single one without it, so that it is highly probable that those *Dipsaceae,* which were not available for observation, would give the same result. In *Scaevola Koenigii Vahl.* the only species of this genus which was to be had and belonging to the family of *Goodeniaceae,* a positive result was obtained and this is interesting, because the family belongs with *Dipsaceae* to the order of *Campanulinae.* On the other hand a number of eighty species, belonging to many different families was examined, but among them not a single one producing Dipsacan was found.

In the year 1911 Prof. Tine Tammes had an opportunity of examining *Morina longifolia Wall.,* a plant belonging to the *Dipsaceae,* but the result was negative. This was interesting in so far as it did agree with the view of Van Tieghem, whose organographical researches led to the result that in characters of inflorescence, flower, fruit and seed this genus differed strongly from other *Dipsaceae,* so that here an anatomical observation proved useful for systematic work. Dipsacan was proved to be a first-rate essential character throughout the whole family of *Dipsaceae.*

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[1]) E. Reinders, Over de rol van levende elementen in het hout bij den transpiratiestroom in boomen. Kon. Akad. v. Wetensch. Amsterdam 1910. The same author, Das Manometer in der Saftsteigungsfrage. Druckmessungen an *Sorbus Americana.* Recueil des Trav. Bot. néerlandais. Vol. X, 1913. p. 1.

[2]) Tine Tammes, Dipsacan und Dipsacotin, ein neues Chromogen und ein neuer Farbstoff der Dipsaceae. Recueil Travaux Botaniques néerlandais. 5, 1908, p. 51; and: Notiz über das Vorkommen von Dipsacan bei den Dipsaceae. Ibid. 8, 1911, p. 369. In the text a few verbal communications were added.

Another paper of Prof. Tine Tammes on a similar subject was published some years afterwards [1]. In *Galanthus nivalis* a chromogen was discovered, which by heating produces an azure-blue colouring matter. This Galanthus blue, as we may call it, was found only in *Galanthus nivalis, G. Imperati, G. cilicicus, G. latifolius, G. Scharlokii,* all of them species belonging to the group of *Archi-Galanthae,* but it proved to be wanting in *Galanthus Elwesii* and *G. graecus*, both belonging to the group of *Neo-Galanthae*. Accordingly Galanthus blue is a substance only occurring in one section of the genus *Galanthus*, and moreover it was shown to be wanting in *Narcissus* and *Leucojum*, both belonging to the subdivision of *Amaryllideae*, and also in twenty other genera, belonging to *Mono-* and *Dicotyledons*, scattered over the whole system. Among them there were several possessing chromogens, like those signalized by Molisch as containing luteofilin, etc.

Summarizing we find that Dipsacotin and Galanthus blue are two colouring matters, which with their chromogens constitute well defined chemical characters, the former distinguishing a rather large family, the latter only a certain number of species of a genus. Thus it is demonstrated here that the same kind of anatomical characters can be highly important in one family and much less so in another, just in the same way as is often the case with organographical characters. By these investigations my thoughtless and imprudent opinions concerning the systematic value of anatomical characters were thoroughly shaken and I was converted to the view that Anatomy is as important, and in the same way important as Organography.

Other investigations taking place in the Botanical Laboratory at Groningen in the same period and still going on in the Koloniaal Instituut at Amsterdam, had a similar influence on my views concerning the systematic value of anatomy.

In the year 1906 they led to the publication of the first volume of the work, entitled "Mikrographie des Holzes der auf Java wachsenden Baumarten", by Dr. Janssonius, of which several other volumes have appeared since then. When Dr. Janssonius began his researches, making use of the method of Pen-portraits, I was firmly convinced that interesting practical results would be obtained as indeed has been the case, but I remember very well that I had many doubts about the question whether the anatomical structure of secondary xylem could be made useful also in a more purely scientific direction. But it soon appeared that the method of Pen-portraits led him to his own original researches, which showed again so clearly that my doubts had no foundation at all.

Still my confession is not at an end. If I had been better acquainted with Systematic Botany, much of the confusion in my mind which has been described above could perhaps have been avoided, although I am not quite sure that before my own experience had led me to a more rational view a better insight could have conquered a conspicuous place in my mind. Be this as it may, it is certainly a fact that at the period of which we are speaking, the value of anatomical characters was fully recognized in taxonomic circles.

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[1] Tine Tammes, Ein neues, einen blauen Farbstoff erzeugendes Chromogen bei *Galanthus nivalis* und einigen anderen Species desselben Genus. Recueil Travaux Botaniques néerlandais 15, 1918. p. 1.

We have seen above on p. 11 when treating the application of anatomical characters in systematic Botany, that there never was at any time an aversion of using anatomical characters in taxonomy. Many investigators, as set forth by Dr. Valeton, attempted to do so and Radlkofer was cited more in detail as an example. But by want of a good micrographical method these attempts always showed a casual character and did not lead to an intensified application.

A convincing proof of the rational notions, entertained by systematic botanists, is afforded by Engler. What he says concerning this subject in his well-known Syllabus[1]) is clear, simple and doubtless quite right. Engler must be considered as a first-rate authority on the field of Systematic Botany; not only that during his long life his busy pen has produced a large number of excellent papers on Systematic Botany, but what is much more important for his influence, he was the leading editor of the two greatest publications of this kind at present existing and used throughout the whole world: firstly Engler und Prantl's "Natürliche Pflanzenfamilien" in two editions, on which the influence of Engler was paramount, Prantl having died soon; secondly "Das Pflanzenreich", an enormous enterprise, which can be completed only after the lapse of many years. In his Syllabus der Pflanzenfamilien Engler begins with a chapter entitled: Prinzipien der systematischen Anordnung, in which the relation between Systematic Botany and Anatomy is considered in an objective and empirical way. Engler does not make the slightest difference with respect to their systematical power between anatomical and organographical characters and he even shows again and again a certain predilection for anatomical characters by naming them in the first place.

Engler's opinion is by no means a recent one, for he proclaimed it years ago in many editions of the Syllabus, for instance already in that of 1892 and then it was probably not for the first time. It is indeed somewhat perplexing that until perhaps one year ago I had never yet taken cognizance of Engler's introductory chapter, cited above. I owned several editions of his Syllabus and used the book from time to time, like all botanists will do. But making no special study of taxonomy I had never thought it necessary to read the introductory chapter, entitled: "Principles of systematical arrangement".

The curious mistake concerning the lack of power of anatomical characters in Systematic Botany was not only mine. It was made by many physiological botanists of the nineteenth century in its latter half and appears in the construction of several text-books. Among botanists of a further generation a better insight is probably at present generally entertained.

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[1]) A. Engler, Syllabus der Pflanzenfamilien, 10 editions, Berlin 1892—1924.

CHAPTER III.

TEXT-BOOKS.

§ 1. Text-books in general.

The terms text-books, hand-books and manuals are often used somewhat promiscuously for designating books of a certain kind to be dealt with here, even now and then for books exhibiting quite another character, for instance when a well-known work of Schenk has been called by the author Handbuch der Botanik, whilst it is in truth only part of an Encyclopaedia of Natural Sciences. I have preferred — partly, because the much used work of Strasburger bears the title of "Lehrbuch", and in its English translation that of "text-book" — the term text-book and will commence by giving a definition of it.

Text-books of Botany are obviously intended to give their readers a more or less complete survey of the whole botanical science in all its branches; so their composition and distribution of subject matter are things of some importance. Therefore it is worth while to examine them from several points of view: in the first place the character of text-books in general, will be dealt with.

Paulsen [1]) has rightly pointed out that "conceptions of sciences are conceptions of problems and in their last intention ought to be constructed in accordance with them." Problems however, being only questions proposed for solution, in their general sense will eventually not present good holdfasts for the distribution of subject matter in a book, especially if it should be a text-book. It is evident that in such a work the reader cannot be content with mention of certain problems, even if accompanied by some explanations, but that what he wants is information concerning solutions of problems, which have been worked out. It is also evident that solutions due to a great number of different investigators and not only due to the author of the text-book must be dealt with. A text-book of Botany consisting only of solutions of problems being the results of the author's own studies, observations and experiments is indeed at present quite inconceivable.

Distribution and arrangement of this subject matter however can be only brought to a good end if we take into account that scientific problems are products of the human mind, and exhibit at any rate a strongly psychological character.

Thus it will be necessary to examine what kinds of men have produced the material, which is brought together in our botanical text-books.

§ 2. The authors of botanical text-books.

Appropriate mentalities and temperaments are wanted for devising and solving scientific problems of different kinds. It must however be stated at once that all botanical problems and researches in the present state of science are occupied with vital phenomena. Not only the functions of the several organs of plants, but also their shapes are considered as belonging to the category of vital phenomena. But everybody will understand that the study of all these phenomena needs many investigators of widely different psychological natures, more so perhaps than in several other sciences, where the variety of problems is more restricted.

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[1]) Paulsen, Einleitung in die Philosophie, p. 20. 1904.

Men with a strong genius for arrangement such as Linné will be great in problems of classification; those who have a gift for chemistry, physics and apparatus, such as de Saussure, Ingen-Housz, Knight, Hales and Sachs will solve problems of metabolism, motion of water through the plant, growth, etc.; for problems of heredity, those possessing a special talent for cultivating plants and well versed in mathematics and statistics, such as Mendel, Hugo de Vries and Johanssen, are needed; for anatomical problems we need persons with a special turn for methods of microscopy, like Oudemans and still more von Mohl and de Bary; oecological problems want persons having power and patience to watch plants in all relations with their surroundings, like Conrad Sprengel, Darwin and Beyerinck in his researches on plant-galls; for morphological problems we need investigators, who like Linné, Eichler, Alexander Braun, Schimper and others are specially adapted for the observation and comparison of shapes and are often good mathematicians.

Botany being curiously many-sided, still other mentalities are needed for doing valuable work which is however not so nearly allied with our present subject, the theoretical subdivision of the science. I may mention here: 1. men with a roaming nature, fitting them for voyagers of discovery. To many of them the most interesting additions to the flora of the world are due. 2. men of a clerk-like nature with a decided taste for the keeping of records. Most useful and daily consulted works have been produced by them, for instance by Durand: Index Generum Phanerogamorum; Daydon Jackson: Index Kewensis and his splendid Glossary of Botanic terms, and Oudemans: Enumeratio Systematica Fungorum; 3. Curators of botanical gardens, called Hortulani in our country. This is a very difficult subject and of no special interest for our present purposes. I hope to return to it at some future occasion.

Evidently the foregoing survey does not imply that the scientists alluded to would possess a mentality or attainments, only developed in the direction mentioned here in relation with certain important botanical problems. Most of them exhibit a genius, more extensive and many-sided, so that some of them may obtain splendid results in two or more fields of research.

It is not astonishing that among the names, cited here as examples of different mentalities, there should appear men, belonging to very different stations of life. University Professors may perhaps form the majority, but clergymen of different creeds are by no means wanting, like Hales, Mendel, Senebier and Conrad Sprengel.

Still more important is the fact of the enormous influence, which medical and pharmaceutical men have had in the development of Botany. It is worth while to say at once something more on this subject, because this influence has stamped a certain character on our text-books, indeed not related with their distribution of substance which principally interests us here, yet influencing their contents in a peculiar way. About the middle of the nineteenth century, the number of those who expressly studied what we now call Biology was very small. Botanical lectures were attended by many medical and pharmaceutical students, whilst the number of young men studying Natural Philosophy was insignificant, because there was no place for them in human society. The foundation of schools for secondary or intermediate instruction had not yet taken place, although it began some years later. Thus young men feeling inclined to Botany and not being wealthy and therefore compelled to make their own way in the world, often studied Medicine or Pharmacy, and among them there were several who became good botanists.

When about the year 1865 my inclination towards Botany was awakening, I sought and found valuable help with physicians and chemists. Three of the botanical University Professors, van Hall (Groningen), Miquel (Utrecht) and Oudemans (Amsterdam) had begun their career as physicians, only Rauwenhoff (Utrecht) and Suringar (Leiden) had studied Natural Philosophy. Dr. v. d. Sande Lacoste, a physician retired from practice, had become a first-rate florist and had written a well-known work on Javanese Mosses; Rombouts and Merkus Doornik, both physicians, wrote together a flora of Amsterdam 1)). When I came to Groningen in the year 1890 as a Professor of Botany, I found on the principal gate-way of the Botanical Garden inscribed with golden letters "Hortus Medicus", an inscription which had deserved to remain as a harmless reminiscence of antique conditions; but it was altered some years later into "Hortus Botanicus". All these circumstances have of course exercised a strong influence upon the choice of plants used for investigation and description, as may be attested by all botanical text-books. Looking for instance through the seventeenth edition 1928 of Strasburger's "Lehrbuch" and confining our attention to the large number of beautiful illustrations, many of them coloured, it will be seen at once how many examples have been chosen among medicinal plants and a perusal of the text will confirm this opinion.

§ 3. The function of text-books in the education of university students.

With respect to the function of text-books in University education I must say something about the relations existing between text-books and University lectures. In order to understand this relation it will in the first place be useful to make a comparison between two proceedings, seemingly removed far from each other, namely between

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1)) Flora Amstelaedamensis, 1852.

what is passing before a court of justice, and scientific studies as they are carried on at Universities.

In countries such as the Netherlands where in jurisprudence an ample preliminary written so-called "instruction" of every case is brought before the courts of justice and is beforehand known to judges and barristers, it might be asked what is the use of a lawyer's plea of defence, because everybody may be censured to know thoroughly all the facts. The answer, curiously enough known only by really good lawyers, is that such a plea is very useful for the defence, because it gives an opportunity for raising the dead "instruction" into a living thing and in some cases this is attained even by small dramatic performances before the court.

A relation of the same kind as between instruction and plea exists between text-books and University lectures. The text-book corresponds to the instruction of the cause: it must be simple and objective, being destined for reference in the study and must give facts and theories in a kind of crystallized, pure and well ordered condition. The task of the lecturer however is one of a more subjective character, he must button-hole his auditors and tell them what according to his present conviction is the kernel of the matter; he may use strong expressions, because he can immediately afterwards soften them, but doing so he can say good things, which his audience will never forget. He is not bound to a strict logical order of his observations and can insert some which are useful, but would ask for another place in his text-book; in a word he can make a living thing of his lecture, which will not fail to procure a lasting impression upon his hearers, not always quite correct perhaps, but this can be mended by a text-book. Thus text-books and lectures are two kinds of teaching completing each other, not to be exchanged at will. If a man writes a really good text-book and, feeling that he had given his best in arrangement and diction, uses it as a layer in his lectures, he will give his auditory only what they can read as well in print, disgusting the better part of them in such measure that they will not stand it, and the frequentation of his lectures will be seriously impaired, and may be reduced to one half or less. A striking, although not botanical example has come to my certain knowledge. If on the other hand a good lecturer should write a mere reproduction of his lectures, perhaps more or less an examination programme, and call this a text-book, he will certainly disappoint those who consult it in their study for necessary informations, which only a true text-book can afford. Even if books of this kind, such as the "Lectures on the Physiology of Plants" of Julius Sachs, are written by first-rate botanists, they cannot be considered as true text-books.

That in botanical lectures objects, experiments, microscopical slides and drawings of all kinds can be shown, is certainly a great advantage for them, but does not interfere with the foregoing remarks.

§ 4. Choice of text-books.

On page 21 of the present work I mentioned five text-books which were chosen as the principal source of our collection of technical terms.

The reasons which led me to the selection of these five books will be dealt with now here. At first I may remark that naturally those books belonging to a former period before the great development of the nineteenth century took place, were left aside. A large mass of organographical terms could indeed be obtained from them, but the same terms enriched by later investigations were to be found, often improved, in all more recent text-books.

Not available for our work, although of a more modern period, was Schleiden's [1] celebrated book "Die Botanik als inductive Wissenschaft", which is in fact a complete text-book of Botany. Although it certainly is imbued with the new ideas which had sprung up about the middle of the nineteenth century and is one of the first manifestations of a new school, its general tenor corresponds to antiquated opinions in too strong a measure, because it exhibits certain revolutionary tendencies against the Linnean school, which affect us no longer. In so far it is not so up to date as we must wish it, so that more recent works, belonging to a later period when the principal trend of botanical science had become more settled, were to be preferred for our purpose. [2]

Schleiden's work had in its time a tremendous influence on Botany and a splendid criticism of it, to be found in Sachs, Geschichte der Botanik, p. 202 et seq. may be warmly recommended to the reader's attention. The work is described here with great impartiality by one who had himself felt its original influence.

Another text-book, which eventually could not be of use for my purpose deserves to be noticed here, namely the Manual of Botany, originally written by Bentley [1]) and since the year 1895 re-edited by Reynolds Green [2]). Of the latter work there appeared three editions up to 1904. At first sight it would seem that we have here a text-book which might wholly satisfy our needs. This manual consists namely of two volumes, the first entitled Morphology and Anatomy, the second Classification and Physiology.

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[1] M. J. Schleiden, Die Botanik als inductive Wissenschaft. Grundzüge der wissenschaftlichen Botanik. I. Methodologische Grundlage. Vegetabilische Stofflehre. Die Lehre von der Pflanzenzelle. II. Morphologie. Organologie. Containing also Taxonomy. First edition 1842—1843, followed by several other editions.

[2] Schleiden's critical genius was his strongest side, but his own researches were not crowned by so much success. His theory that the embryo of the higher plants was formed by the top of the pollen-tube had never a great success and ultimately was quite forgotten. This process took place already during his lifetime and as he became very old (1804—1881) he was in a certain measure forgotten, so that botanists of my generation thought that he was dead long since. A curious, historical anecdote in connection with these facts may perhaps interest some of my readers. About the year 1877 Prof. Rauwenhoff, speaking of Schleiden, told me that he had recently met him at a scientific congress in Germany, and of course this astonished me in a high degree. Soon afterwards I told this small occurrence to Prof. Donders, the celebrated physiologist and ophthalmologist of Utrecht, who said that a similar case had been observed by him at a scientific congress. At his congress there was present Schwann (1810—1882), the world-famed founder of the theory, long since accepted as a fact, that the cellular structure of plants was also general in the animal kingdom; a man who had like Schleiden outlived his fame. Donders knew him personally and stood speaking with him for some time. After this another member of the congress came and asked with whom he had been speaking. Donders called the famous name and the unexpected news ran through the congress like wild-fire. Donders said that if St. Peter himself had appeared at a Catholic Council of Rome, the astonishment could scarcely have been greater.

Here indeed a praiseworthy distribution of materials has taken place, a first step which must be taken for reaching the formation of a separate General Morphology, such as I have described above.

But the author ought to have taken some further steps in order to reach our purpose, and in default of having done so, his distribution although good in itself has remained sterile with respect to the formation of what I call a General Morphology.

The separation of Morphology and its condensation into the first volume has not been carried out so far that it can be of real use in Phytography. Several terms, like thallus, spores (macro- and micro-), gametes have indeed been transferred to the first volume. But many purely morphological terms in our sense of the word have remained in the section on classification of the second volume: mycelium, plasmodium, carpogonium, sporangium, tetraspore, ascus, basidium, hymenium (hymenial layer), gills and trama may serve as examples.

A second observation to be made here is that the author does not take into account Phytography as an essential part of Botany, for he reckons Descriptive Botany (Vol. I. p. 2) with horticultural, economic and other branches of the same kind as an applied, botanical science.

Therefore it may be said that, commendable as Bentley-Green's separate morphological volume may appear from a general point of view, a real general Morphology, such as is wanted for our Phytography has not been formed.

Because there were no special reasons for dealing with this book in other particulars, no further analysis of it will be made. Yet we must not forget that the conception of a separate first volume dealing with morphology, is indeed very plausible and it secured for the author as a reward two important advantages. In the first place he could not be seduced to the divisions of General and Special Botany to be criticised below; in the second place he has remained free from the idea that Anatomy belonged to Physiology and not to Taxonomy, already criticised on p. 504.

A text-book including a chapter on General Morphology in our sense not being available, I chose the following five books which cover together a period of about sixty years, namely those of Oudemans [3]),

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[1]) R. Bentley (1823—1895), A Manual of Botany; including the structure, functions, classification, properties and uses of plants. First edition 1861.

[2]) J. Reynolds Green, A Manual of Botany, London. Vol. I. 1895. Vol. II. 1896. Third edition 1904.

[3]) C. A. J. A. Oudemans, Leerboek der Plantenkunde, Utrecht-Amsterdam; vol. 1. Morphologie, Anatomie, Physiologie 1866—'67; vol. 2 Phytographie, Taxonomie, Planten-Geographie, 1868—'70.

Sachs ¹), Van Tieghem ²), Oudemans en de Vries ³) and Strasburger ⁴).

The book of Oudemans was published not long before the first edition of Sach's Lehrbuch, and in its time it was a striking advance on its predecessors.

Oudemans linked together in his botanical career the old and the new schools of Botany. Originally he came out as a thorough-bred taxonomist of the existing schools of Linné, De Jussieu, De Candolle and others. But he did not remain stranger in other regions opened during the first half of the nineteenth century. He was personally involved in the rise of microscopical research, being a first-rate microscopist himself, as I can testify as his grateful disciple. By his researches he became the first authority among mycologists in our country and may be still so considered. Further it is well-known that he was the first to introduce microscopy into Pharmaceutical Botany ⁵). Thus he was the first who wrote a complete botanical text-book comparable with our modern text-books.

§ 5. Analysis of Text-books.

A. The place of Morphology in our five textbooks. Treating this subject it will be necessary to separate Organography in the sense of external differentiation from Anatomy, representing internal differentiation. Studying this subject it soon appears that the distribution and arrangement of organographical facts in principle is connected with the division of the plant kingdom into those groups, which form what is called the Natural System. But the way in which the organographical facts are linked together with the groups to which they belong, is by no means always the same.

Beginning with the Organography of the higher plants we may say that in modern text-books, after a lapse of two hundred years, we can still easily recognize its Linnean origin. In his Philosophia Botanica Linné laid the foundation of the Organography of the higher plants which in many respects is still existing, so that a large number of organographical terms due to Linné is at present in daily use. On the other hand however after a couple of centuries many alterations have occurred, in conformity with the results obtained not only by the application of new methods such as the study of development, comparative investigations and the use of the microscope, but also by the general progress of scientific discernment. Therefore perusing modern text-books we find an organography of the higher plants altered indeed, but clearly showing the distinctive marks of its origin,

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¹) J. Sachs, Lehrbuch der Botanik, 4 ed. Leipzig 1874.

²) Ph. Van Tieghem, Traité de Botanique, 2 ed., 2 vol, Paris 1891.

³) C. A. J. A. Oudemans en H. de Vries, Leerboek der Plantenkunde, 3 ed. Nijmegen 1895, vol. 1. Plantenphysiologie, by de Vries; vol. 2. Vormleer en rangschikking, by Oudemans, vol. 3. Handleiding bij het vervaardigen van mikroskopische praeparaten uit het plantenrijk, by de Vries.

⁴) Strasburger, Noll, Schenk und Schimper, Lehrbuch der Botanik, 17 ed. by Fitting, Sierp, Harder, Karsten, Jena 1928.

⁵) Moll and Janssonius, Botanical Pen-portraits, the Hague 1923, p. 1.

so that I may call it here "an enlarged and modified Linnean Organography". Yet it must be kept in mind that there are many organs belonging to external differentiation, like antheridia, archegonia, spores, gametophytes, etc., which are wanting or occur only in much altered shapes among the higher plants, so that they are not dealt with in our enlarged Linnean Organography. Moreover it must be understood that this Linnean Organography is applicable without reserve only in the groups of *Angiospermae* and *Gymnospermae*. Practically not applicable at all is it in *Algae*, *Fungi* and *Thallophyta* in general, because organs such as leaves and stems, although occurring in a few cases like *Caulerpa* and *Sargassum* are as a whole wanting in these lower plants. It may be said that Linné and many of his followers were ignorant with respect to the Organography of these plants, which had to wait for the investigators of the nineteenth century, mentioned in Chapter II.

Between *Angiospermae* and *Thallophyta* transitional stages are formed by *Bryinae* and *Pteridophyta*. The vegetative organs of both as a general rule are of the same kind as those of the higher plants, although roots are wanting in Mosses. But the Organography of reproductive organs such as sori, sporangia, spores ¹), prothallia, protonema, sporogonia, antheridia and archegonia is by no means comparable with what we have called enlarged Linnean Organography.

Concerning the distribution of enlarged Linnean Organography in our text-books, the following may be said. In Oudemans we find it under General Botany, forming part of and introduction to Physiology. Van Tieghem's conception, though it differs from that of Oudemans in a point which is of subordinate importance here, is essentially the same as that of Oudemans. In Oudemans and De Vries, where there is no division into General and Special Botany, Oudemans treats Linné's enlarged Organography in a special

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¹) In Strasburger's edition of 1928 on p. 301 we find a passage concerning the groups *Thallophyta*, *Bryophyta* and *Pteridophyta*, which are called since Linné *Cryptogamae*, but according to the author it is preferable to call them *Spore-plants*, notwithstanding as he remarks himself, the higher plants are also provided with spores in their seeds. *Cryptogamae* is not much more than an obsolete term, expressing a want of knowledge and no characters by which such a group could be distinguished. It has long since fallen asunder into the groups *Thallophyta*, *Bryophyta* and *Pteridophyta*. Its revival is certainly undesirable, but its being replaced by the name spore-plants, though often used, is a most unhappy choice, because we know, that in *Spermatophyta* spores are not at all wanting; in other words, that they appear throughout the whole vegetable kingdom. But in *Spermatophyta* they have been termed embryosacs and pollen-grains. I make mention of this curious passage, because it is a proof how thoroughly the importance of such a term as spores can be underrated in an up-to-date and good text-book. The reader who consults in the synopsis the articles S No. 78—S. No. 134 will understand at once that a wider horizon may be opened by a real General Morphology. We will then see how for want of a real General Morphology, where all facts belonging together can also be dealt with together, Hofmeister's splendid discovery of the alternation of generations, although very well-known and considered as most important, yet has failed to exercise its full legitimate influence upon our botanical considerations.

volume preceding and combined with the volume on Taxonomy, so that its former relation with Physiology has here been abandoned. Strasburger in conformity with the fact that his text-book has been written by a combination of four different authors, shows a stronger division of Linnean Organography. A part of it, chiefly dealing with vegetative organs, has found accomodation in Part I, General Botany, Section I, Morphology. Those parts however treating flower, fruit and seed are placed in Part II, Special Botany, Section II, *Spermatophyta*. Sachs will be dealt with below.

Before leaving our enlarged Linnean Organography I must say a few words with regard to a couple of passages in Sachs and Strasburger containing promises, fulfilled in my Synopsis of General Morphology.

In Sachs the modified Linnean Organography has not expressly been treated and in its place some new points of view have been introduced, which deserve our attention and may be dealt with here. In support of these several points of view he cites a considerable number of authors, like Nägeli, Hofmeister, Pringsheim, Hanstein, Leitgeb, Warming, Alexander Braun, Schwendener, Bravais, v. Mohl and other well-known names. Sachs mentions for the first time in a text-book the terms thallome, caulome and phyllome in their reciprocal relations, trichome, the term rhizome for root being not available, because it has long since possessed in Botany another generally accepted meaning. The phenomena of symmetry and branching are also dealt with by Sachs in separate divisions. Strasburger in the first section of General Botany entitled Morphology, deals with the same subjects, but with an important addition concerning Alexander Braun's order of sequence of cormi, leading to the distinction of haplocaulescent, diplocaulescent, triplocaulescent, etc. plants.

The introduction of these several subjects is very important, because their further development will enable us to lay the foundations of a real General Morphology, so necessary for the progress of Phytography.

Passing now to Anatomy comprising Cytology and Histology, we find that here differences between higher and lower plants are of much less account than we found them in Organography. The Cytology of the whole vegetable kingdom presents a high degree of uniformity. The differences in Histology are certainly much greater. Taking for instance the Histology of Dicotyledons with its epidermis, vascular bundles, secondary xylem and phloem, etc. against that of *Spirogyra* or *Ulva*, the difference is important, but certainly by no means more considerable than that between thallome, cormus and root.

Another interesting fact concerning the place of Anatomy in our text-books is a strong tendency to bring it into connection with Physiology. This has been done in Oudemans, Van Tieghem and Oudemans-De Vries, just as if it ought only to serve as an introduction to Physiology, and an influence upon Systematic Botany were out of the question. We meet here with a want of harmony existing between modern Systematic Botany and our text-books, which can be explained by historical retrospection, as has been done on p. 504.

B. Critical remarks. Proceeding now to the critical remarks promised above, I mention in the first place that in all our text-books we find the great Sections of Physiologic and Systematic Botany or Taxonomy, and they at any rate deserve prominent places. These Sections no doubt correspond to different and essential problems. That of Physiology is in the first place metabolism, comprising anabolism and katabolism and in the second place interchange of energy 1). That of Systematic Botany is the problem of the Natural System in the sense, which at present is generally allowed to this term. These two Sections need no further defence or explanation and will certainly persist, although I will show beneath that the persistence of Physiology as a more or less independent Section of pure Botany is somewhat uncertain.

Be this as it may, we find that in practice Physiology and Taxonomy are represented at many modern Universities, for instance Groningen and Utrecht, each by their own Professor, whilst in conformity with our text-books Organography, Anatomy and here and there Plant-Geography belong to the resort of one of the two Professors or to that of both according to personalities and local circumstances.

Another primary way of dividing the subject matter must now be dealt with which does not deserve a favourable criticism. In Oudemans, Van Tieghem and Strasburger we find a principal division into two Sections called General and Special Botany. The division into these two principal Sections is wanting in Sachs and Oudemans-De Vries. In this connection it must moreover be noticed that another Section, which ought to be considered as one of the first order, viz. Geography of Plants, has been added to General Botany. But it has found a good place only in Oudemans and Van Tieghem. In the other text-books it is wholly wanting or (in Strasburger) mentioned only somewhat incidentally, also in General Botany.

A division into a general and special part is certainly very well possible in several Sciences. The late renowned psychologist Heymans divided his Science into General Psychology i.e. the study of General Psychological laws, and Special Psychology i.e. the study of the different temperaments, and his last work was devoted to the writing of a book, dealing with this subject 2).

In our Synopsis the reader will find a division into general and special Histology, the first of these treating the histology of all plants and all their organs, whilst special Histology treats those parts of histology applicable only to certain organs, like roots, leaves, etc. I

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1) W. Pfeffer, Pflanzenphysiologie, 2 ed. 1. Bd. Stoffwechsel, Leipzig 1897, 2. Bd. Kraftwechsel, Leipzig 1904.

2) G. Heymans, Inleiding tot de speciale Psychologie, 2 Vol., Haarlem 1929. A German translation of this work was prepared by Heymans, just before his death, and will certainly be published soon.

will show however that the division of General and Special Botany cannot be compared with the foregoing examples.

In order to pass a judgment upon this division of the first order we must keep in mind, that the chief subject of General Botany is Physiology, as we have seen with the addition of Plant-Geography, and that of Special Botany is Systematic Botany or Taxonomy. Knowing this we will be able to make certain suppositions about the meaning of the two terms, concerning which we find no particulars mentioned in any of our text-books.

It may be supposed that by General Botany was meant that part, in which subjects of Physiology concerning all plants together are dealt with, so that a single plant-individual may be to some extent sufficient for solving certain problems, whilst on the other hand in Special Botany the knowledge of special groups of plants is paramount, so that a single plant-individual can never be used for investigations in this branch of learning. Several objections however may be brought forward against a division on such grounds, in which there is indeed some truth but also an alarming absence of argumentation.

In the first place it is true that in Special Botany, comprising Taxonomy, special groups of plants are dealt with, yet the same in a certain sense holds good for General Botany containing Physiology, in which groups such as autotrophous, parasitic, saprophytic, aquatic, xerophytic, anaërobiotic and many others play an important part. But it must be conceded that such groups in Physiology are more incidental and have not the importance of groups in Taxonomy, where they form the aim and the result of all investigations.

A more important objection is that the terms "general" and "special" are scarcely fit for indicating the problems characteristic for the two principal divisions of Botany. If we know nothing about the difference of two problems, than that one is concerned with all objects and the other only with groups of them, our information is indeed a very poor one, and we have a right to ask for more.

Lastly the admission of Plant-Geography into General Botany is by no means an elegant expansion. Everybody will admit that the problems of Physiology, which forms the principal part of General Botany, are not the same and not even nearly related with those of Plant-Geography. It is clear that the distribution of plants on the earth is a problem which deserves the place of an independent principal division and cannot be placed in the same division with Physiology.

Taking all these objections together the question arises, how it is possible that a division such as that of General and Special Botany can have been devised by authors of so undoubted and well earned authority as Oudemans, Strasburger and Van Tieghem, although this same authority may explain that the divisions were generally accepted. Perhaps the attention of these authors was absorbed in such a measure by the multitude of interesting questions they were dealing with in their book, that they considered the general distribution of their materials as a subject of inferior importance, but I cannot refrain from mentioning here that the deeper reason for choosing the unhappy terms of General and Special Botany must be sought elsewhere and did not appear at the surface.

If we ask why in choosing titles for both divisions the authors of some text-books did not simply use the terms Physiology and Systematic Botany for designating the two divisions of the first order, it is more than probable that they were kept back by the fact that to Physiology and Taxonomy they thought themselves compelled to add large masses of Morphology, which could not be suppressed or concealed.

No doubt this circumstance justifies in a certain measure their choice and at any rate excuses it more or less. In so lax a conception of the term "General" as meaning only "comprising a variety of different subjects", it cannot astonish that Geography of Plants was admitted into this division. But the result of all this is not simple and clear; I dare say that the terms General and Special Botany will in future disappear without being missed.

Summarizing what has been dealt with in the foregoing pages, we find that indeed good text-books can very well help us in procuring a sufficient set of technical terms for purposes of Phytography. But I am driven to the conclusion that the distribution of Morphology, external and internal, in our text-books is a very defective one and that a real General Morphology in the sense given to it above is sorely needed. In course of time this must appear as a natural introduction into Botany, not indeed its alpha and omega, but certainly its alpha, which will always remain necessary for those who wish to study the more essential problems of Botany: Physiology, Taxonomy and Plant-Geography.

CHAPTER IV.

ANTICIPATIONS.

Prophesying the future is always a risky undertaking. Nevertheless there are cases in which it is permitted to say something concerning future events, because they have already partly taken place and their future development in a certain direction seems very probable. Therefore I will say something here of a predicting nature about the probable place of Physiology in future text-books of Botany. To this will be added something about Oecology and its place in those same text-books.

What I have to say is related with the peculiar character of Zoology in contrast with that of Botany. The latter is a science of wider scope, although certainly the variety of types, composing the animal kingdom, is larger than that in the plant kingdom. Beginning with Botany we have seen in the foregoing chapter that at present the distribution of subject matter in a botanical text-book ought to be as follows:

1. Section of General Morphology, needing no further explanation after all that has been said about it.
2. Systematic Botany or Taxonomy, which can be treated more thoroughly, more space being at disposal by the disappearance of purely morphological data.
3. Physiology.
   a. Oecology, see further below.
   b. Metabolism and transformation of energy.
4. Geography of Plants. This must certainly be considered as a subdivision of general Geography, of which the problem is a knowledge of the earth as the dwelling-place of mankind, if it shall not be a hopeless and meaningless conglomerate of other sciences, like Astronomy, Geology, Politics, Economics, History, etc. etc. But it must be conceded that Plant-Geography has moreover its own, more botanical phase.

This is certainly a comprehensive programme, which in substance has existed sixty years and longer, for the separation of general morphology although very important for our present purposes has nothing added to its comprehensiveness.

Zoology however has long remained without physiology, thus exhibiting a more strictly morphological and taxonomical character, and it is only of late years that a physiological direction has been taken and is represented by special university professors as has lately been the case, for instance at Groningen.

When I came into Natural Philosophy, some sixty years ago, this difference of Botany and Zoology was indeed very great and to choose Zoology meant nothing less than abandoning all hope of coming to physiological investigations.

I was so firmly convinced of this that when after having become a candidate of Natural Philosophy, Professor Selenka at Leiden, asked me to become a zoologist and to come into his laboratory as his conservator, I was obliged to decline this offer. I felt so strongly interested in physiological problems, that I could not gather the necessary resolution for leaving them altogether, although Selenka's offer was in all other respects most acceptable and even opened perspectives of future promotion. I felt as if accepting was like marrying for fortune's sake, whilst loving another woman.

Overstrained as this may seem at present, it was the consequence of the condition of animal Physiology in those days. The Physiology of men was studied with great intensity in the Faculty of Medicine by first-rate investigators, like Johannes Müller, Helmholz, Donders, v. Deen, Moleschott and many others. Donders and v. Deen had built their special laboratories for this branch of science, and it seemed that the way to physiological research led exclusively through Medicine.

All this has been altered now and it seems evident that botanical and zoological Physiology could very well be united together, the more so, because some steps have already been taken in such a direction. The term Biochemistry is at present often used for designating the knowledge of metabolism in plants as well as in animals. Two representative works, one of Czapek concerned with plants, and the other of Oppenheimer concerned with man and animals, may be cited here. Fr. Czapek, Biochemie der Pflanzen, was published for the first time in the year 1905, in two volumes. In the years 1913—1921 a second edition in three volumes saw the light, and the author having died, a third unaltered edition became necessary in 1922. C. Oppenheimer, Handbuch der Biochemie des Menschen und der Tiere, is a still more bulky work than that of Czapek; it appeared from 1924 to 1930 in nine volumes and an Ergänzungsband.

The works of Czapek and Oppenheimer are to be found in every laboratory, with several smaller ones, old and new. They are occupied not only with metabolism, but also with many subjects pertaining to exchange of energy in living beings, so that they very well could be combined into a General Physiology of animals and plants together, and I consider the chance of such a thing happening by no means illusory, and quite in the line of scientific development. If such a scheme were worked out, there would be gained a much broader basis for physiological research than hitherto existed. But it is evident that then Plant-physiology would cease to exist as a section of Botany and would disappear out of botanical text-books.

I suppose that a branch of Biology might arise, which I will provisionally call Bioenergetics, comprising Biochemistry, Biophysics and Biomechanics. It might be represented at universities by a Professor, able to give lectures and further guidance to students, bearing a general character. This could be very well reached, although it might perhaps be impossible to find, like in the time of Linné, a biologist, equally versed in the botanical and the zoological direction, so that with respect to personal investigations some variety would be probable.

As I said above, the section concerned with Physiology would then cease to form part of botanical text-books, which in itself could create no objection, because it would receive a good place elsewhere. But it would also involve the disappearance of the chapter on Oecology, and it is clear that there would be no place for this interesting subject in our new Bio-energetics, whilst it is essential and even indispensable in Botany.

Oecology is a term introduced by Haeckel ¹) for designating the doctrine of economy, mode of life and reciprocal, external relations of living organisms towards each other, in fact all relations of organisms with the surrounding outer world, which are often called adaptations. Schwendener has done splendid work in this direction, and as an example may be cited his investigations, published in the year 1874 ²) concerning the anatomical structure of Monocotyledons and

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¹) E. Haeckel, Generelle Morphologie der Organismen, Berlin 1866. Bd. I. p. 8.

²) S. Schwendener, Das mechanische Prinzip im anatomischen Bau der Monokotylen, Leipzig 1874.

showing that the distribution of thick-walled fibrous tissues giving the necessary firmness to the parts of those plants corresponds in a really astonishing measure to the principles followed by engineers, when they try to stiffen their structures with a minimum use of material.

It is evident that phenomena of such a kind are strongly connected with Physiology, for which Oecology in many respects forms a basis, whilst in Physiology itself the physical and chemical causes are studied, of which oecological phenomena are the result. Thence in distributing the subject matter in a botanical text-book, there is, as has been mentioned above, not a slightest objection against a division of a physiological section into Oecology and chemico-physical Physiology. But Oecology cannot be transplanted with botanical Physiology into our Bioenergetics, whilst on the other hand it cannot be missed in Botany. I consider it therefore as a happy circumstance that Warming [1]) has laid the foundation of what he called the Oecological Geography of Plants. For because Plant-Geography will certainly remain a section of ordinary Botany and is not predestined to disappear, there is in this way procured a good place for the treatment of so important a subject as Oecology certainly is, in future botanical text-books. Therefore if the above projects should ever be worked out, the composition of a botanical text-book, considered as presently necessary, and given on p. 521, would then be again altered and become as follows:

1. General Morphology.
2. Systematic Botany or Taxonomy.
3. Geography of Plants, including Oecology in a due proportion.

It is obvious that in such a way the composition of Botany would return in some measure towards its more primitive shape in which Taxonomy played a very important part.

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[1]) Eug. Warming's Lehrbuch der Oekologischen Pflanzengeographie 3 Aufl. von Eug. Warming und P. Graebner. 1918.

In the year 1909 there was published under Warming's guidance an English edition, entitled "Oecology of Plants" by Percy Groom and J. B. Balfour.

GEOGRAPHICAL INDEX

ALPHABETICAL INDEX

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